ELECTRICAL ENGINEERING

APRIL 1960
Vol. 79, No. 4

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NSF Photo

THE COVER: Giant balloons designed to gather information for high-energy cosmic ray investigations were launched during Operation Skyhook 60 from the deck of the USS *Valley Forge* in the Caribbean area. The operation was sponsored by the National Science Foundation and the Office of Naval Research. Story on P. 341.

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THE IDEA THAT GREW FOR 100 YEARS

At Bell Laboratories, M. Uenohara (left) adjusts his reactance amplifier, assisted by A. E. Bakanowski, who helped develop first suitable diode. Extremely low "noise" is achieved when certain diodes are cooled in liquid nitrogen.

First practical diode for amplifier, shown here held by tweezers, was jointly developed by A. E. Bakanowski and A. Uhlir.

How basic scientific ideas develop in the light of expanding knowledge is strikingly illustrated by the development of Bell Laboratories' new "parametric" or "reactance" amplifier.

Over 100 years ago, scientists experimenting with vibrating strings observed that vibrations could be amplified by giving them a push at strategic moments, using properly synchronized tuning forks. This is done in much the same way a child on a swing "pumps" in new energy by shifting his center of gravity in step with his motion.

At the turn of the century, scientists theorized that *electrical* vibrations, too, could be amplified by synchronously varying the *reactance* of an inductor or capacitor. Later amplifiers were made to work on this principle but none at microwave frequencies.

Then came the middle 50's. Bell Telephone Laboratories scientists, by applying their new transistor technology, developed semiconductor diodes of greatly improved capabilities. They determined theoretically *how* the electrical capacitance of these new diodes could be utilized to amplify at *microwave* frequencies. They created a new microwave amplifier with far less "noise" than conventional amplifiers.

The new reactance amplifier has a busy future in the battle with "noise." At present, it is being developed for applications in tropospheric transmission and radar. But it has many other possible applications, as well. It can be used, for instance, in the reception of signals reflected from satellites. It is still another example of the continuing efforts to improve your Bell System communications.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

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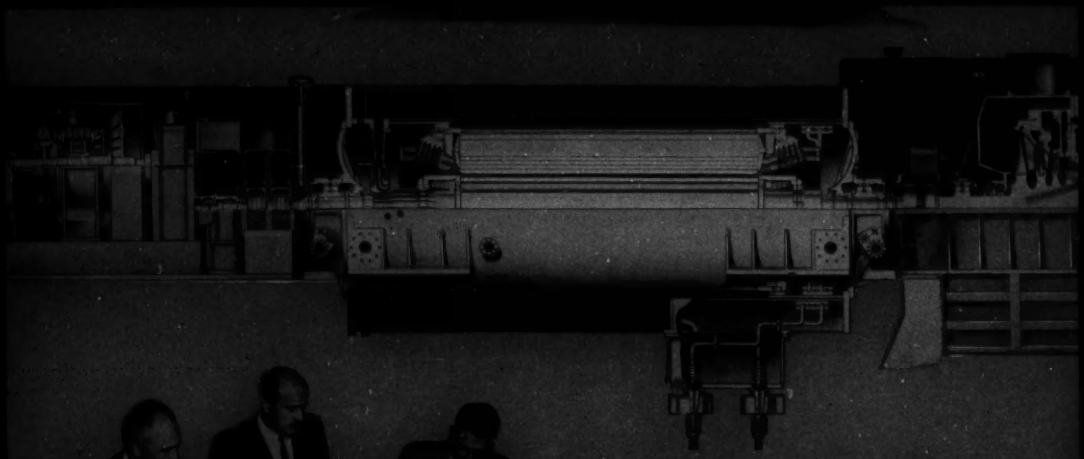


Design Firsts by Allis-Chalmers

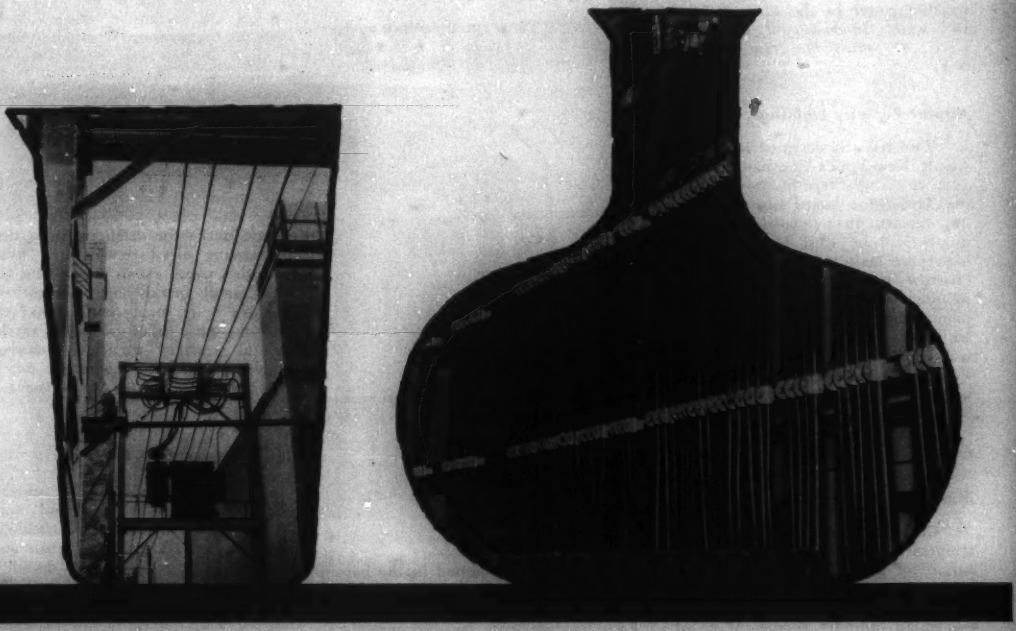
1926	Side-crossunders
1934	Separate nozzle chests
1936	Thrust-type hydrogen seals
1941	Nonsliding thrust-bearing pedestals
1948	Supercharged axial ventilation

Designing today for tomorrow's power needs, Allis-Chalmers experienced, forward-thinking engineering staff has pioneered higher ratings and unique arrangements for steam turbine-generator units . . . originated and patented many of the design features now adopted as industry standards for such equipment.

PACING

Engineering know-how and the results of extensive research and development programs are confirmed on the large turbine test pits. During the past few years A-C has spent millions of dollars expanding and modernizing manufacturing facilities like these to assure that design excellence created on the drawing board is translated into the finished product.

In the modern General Cable laboratories, some of America's foremost rubber chemists create, test and evaluate new insulation compounds in a continuous program of research and development. Materials for standard service conditions and special constructions to satisfy unusual requirements have all proven their worth in superior performance in power and control cables over many years. A few of the basic compounds from General Cable's long list are briefly described on these pages.



THERMAX-W

and many other compounds in the rubber group are available for low and moderate voltage power cable service in wet locations, where high temperatures are encountered or where high current carrying capacity is required.

GENCASEAL (PVC)

in the thermoplastic group, as well as high-molecular-weight polyethylene, which is another outstanding General Cable thermoplastic insulation.

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New and Improved Products . . .

Lead Sulphide Photocell . . .

An extremely sensitive photoconductive cell utilizing uncooled lead sulphide will find useful application in spectroscopy and pyrometry because of its spectral response range of 0.3 to 3.5 microns. Sensitivity with tungsten light is 3.0 ma per lumen. Black body sensitivity at 200C is 180 volts rms per watt and the signal-to-noise ratio is 150. The minimum detectable power of the *61SV* is 5.0 x 10^{-8} watts. *International Electronics Corp., 81 Spring St., New York 12, N.Y.*

Airport Runway Lighting . . .

Two recently designed lamps will supply New York's International Airport with a new type of runway lighting. Quartzline lamps with incandescent filament in a tube of pure fused quartz will be used for all-weather high-speed taxiways and turnoffs. The "narrow gage" system for runway lighting will comprise two series of parallel light fixtures embedded flush with the runway to give a railroad track effect for the pilot. Each 100-watt PAR lamp used in these fixtures will be capable of producing 90,000 peak beam candlepower for severest weather conditions. *General Electric Co., Nela Park, Cleveland 12, Ohio.*

Midget Bead Thermistor . . .

Currently used for measuring temperature on the inside and outside surface of the Polaris and Atlas missiles, these thermistors are so small that they can easily pass through the eye of an ordinary needle. Made of

Courtesy Ostergaard

manganese nickel oxide, the thermistors can be used in medical applications inside a hypodermic needle to measure blood temperature. The thermistors can also be used in r-f power measurements in the microwave field and in the measurement of low gas pressures measuring temperatures ranging from —76 F to 572 F. *Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J.*

Transistorized Readout Tube . . .

Called Trixie in deference to its predecessor, this latest advancement of the Nixie uses ten medium-voltage

n-p-n transistors mounted in the base to drive each of the cathodes that provide the illuminated configurations. Each module can be triggered by signals as low as 3 volts and current of 300 microamperes resulting in visual readout at the very lowest power input level. *Burroughs Corp., Electronic Tube Div., P.O. Box 1266, Plainfield, N.J.*

Preprinted Adhesive Film . . .

All types of little blocks, standard parts, wiring diagrams, and other printed matter used repeatedly on drawings can now be printed in advance on Dulseal and applied when needed. Saving time and manpower required to letter each job individually, these transparent adhesive films have a delayed setting action that permits the material to be relocated several hours after application. Left untouched, the film's adhesive "sets" form a permanent bond with the paper or cloth. *Keuffel & Esser Co., Third & Adams Sts., Hoboken, N.J.*

Hour Meters . . .

A line of sealed, rugged hour meters will tell at a glance the cumulative operating time in hours and minutes of any machine, tool, or equipment run with 120 to 480 volts a-c. Typical applications include machine tools, air compressors, air conditioners, pumps, refrigeration units, motor-generators, power conveyors, and rental tools. *Hobbs Division, Stewart-Warner Corp., Springfield, Ill.*

Magnetizer . . .

Here is a handy, inexpensive gadget that can be plugged into any electric outlet for magnetizing or demagnetizing files, screwdrivers, "fishing" wire, pliers, screws, nuts, bolts, or other small metal objects. Another good use is for magnetizing crankcase dip-sticks and drain plugs to catch harmful metal particles floating around in the oil. *Progressive Sales and Service Inc., Box 131, Sawyer, Mich.*

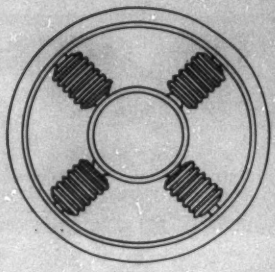
Tiny Precision Switch . . .

The new Klixon AT1-1 establishes something of a record for miniaturized hermetically sealed switch design. Hardly larger than an aspirin tablet, the single-pole double-throw device weighs less than 1/28 ounce and has a current capacity of 3 amperes at 28 volts d-c. The extreme size reduction was made possible by using a unique, snap-acting, "W-blade" element. *Texas Instruments Inc., 34 Forest St., Attleboro, Mass.*

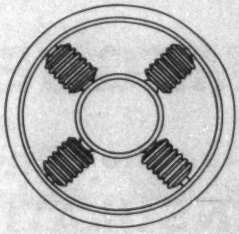
Punch Press Computer . . .

Designed for high-speed punch press operation, this numerical control system uses logical decision-making elements found in electronic computers to provide simplified programming and operator control. Information entered on a punched paper tape tells the system the size of the desired piece and the number, type, and location of the holes. Through internal logic, the system determines the sequence of operations. *Auerbach Electronics Corp., 109 N. Essex Ave., Narberth, Pa.*

(Continued on page 10A)



Standard Bus—Up to 90°C The AIEE standard, coupled with I-T-E quality construction—lowest losses.



High Temperature Bus—105°C Reduces conductor size by 15% with correspondingly lower cost—but with increased losses.

Pick the bus that saves you the most

Only I-T-E Isolated Phase Bus is available in such a variety of designs to save you money. Your selection of the type of bus to buy depends on evaluation of both original cost and losses, plus careful consideration of the desired method of operation.

All I-T-E bus types are backed up by the engineering and laboratory experience of I-T-E. Design constants are so well known from theory and test that the most economical conductor to use for any ampere rating and voltage has been computer calculated.

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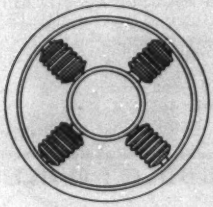
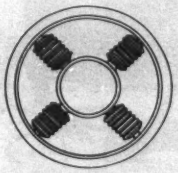


Forced-Air Cooled Bus Even smaller in size, with still lower material costs —still higher losses.



Liquid-Cooled Bus Minimum conductor size—highest losses.

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INSULATION TESTERS

For repetitive insulation resistance tests on a production basis . . . and for time-resistance tests . . . nothing equals the Meg Type Rectifier-Operated Insulation Tester for convenience and reliability. The plug-in rectifier source of power permits the instrument to be used without hand cranking. A constant-voltage feature reduces pointer fluctuations which may occur when testing equipment having appreciable capacitance, such as larger generators and long cables. Standard units are available for 500 or 1000 volts d-c test potential and for ranges up to 2000 megohms.

Other Megger Insulation Testers include hand-crank models and Dual-Operated sets. The latter are versatile instruments with rectifier for repetitive or time-testing that can be disconnected for hand-crank operation in the field.

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. . . for locating cable faults by impulse tracer method . . . for D-C proof testing. Applicable to aerial and buried cable as well as lead-covered cable in ducts. Transmitter can be connected to 115 V, 60 cps supply.

MODEL 3-2—Output voltage up to 25 kv. Discharge capacitance 1.65 muf. For use on cable up to 15 kv rating.

MODEL 4-2—Output voltage up to 15 kv. Discharge capacitance 2 muf. For use on cable up to 5 kv rating.

MODEL 5-2—Output voltage up to 5 kv. Discharge capacitance 16 muf. For use on cable up to 1 kv rating.

Write for BULLETIN 65-EE

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• SPEED MEASURING INSTRUMENTS
• LABORATORY & SCIENTIFIC EQUIPMENT

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New & Improved Products

(Continued from page 8A)

High-Speed Electronic Flash . . .

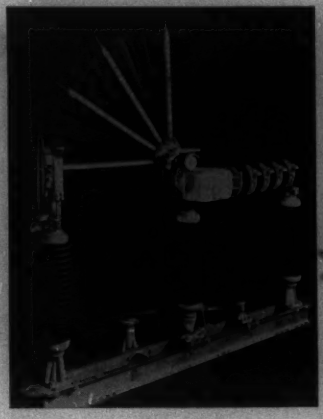
Developed to meet the needs of high-speed framing cameras, this compact and portable unit will deliver a single flash of 1,200 watt-seconds. Duration settings are 8.70, 11.15, 14.75, and 22.25 milliseconds. Rise and decay times of the square pulse are in the order of 40 microseconds. *Beckman & Whitley Inc., San Carlos, Calif.*

Stereo Microphone . . .

Nonprofessional stereo recordings are now feasible with this microphone. Consisting of two dynamic coil microphone elements set at right angles and mounted in a single housing, the unit has high sensitivity, the output being only 50 db down at 1 volt at an input pressure of 1 μbar/cm². *North American Philips Co., 230 Duddy Ave., Hicksville, Long Island, N.Y.*

Hybrid Switch . . .

Resembling a load interrupter switch in appearance but working more like a circuit breaker, this family of switchgear embodies a new concept in high-voltage interruption. The apparatus is mounted, opens and closes, and isolates circuits visibly with air like a load interrupter. But like a



circuit breaker with its trip-free feature and latch-check switch, it carries current continuously through its interrupting unit, trips from stored energy, and has a positive sequence control built into its mechanism to withstand short-time surges. *S & C Electric Co., 4435 N. Ravenswood, Chicago, Ill.*

(Continued on page 12A)

Natvar TERAGLAS*

A NEW CLASS B INSULATION HAS RESILIENT WEAVE AND HIGH DIELECTRIC STRENGTH UNDER STRETCH

Natvar Teraglas is a new flexible insulating material comprising a base fabric, woven from polyester (polyethylene terephthalate, or "Dacron") warp yarns and continuous filament glass filler yarns, coated with an improved varnish, possessing exceptional dielectric strength under elongation. It will withstand Class B (130°C) operating temperatures.

In view of the higher dielectric strength of Natvar Teraglas compared to bias varnished cambric, thinner sections or fewer layers may be used to provide the voltage breakdown protection desired. Consequently, at comparable tape prices, a significant saving may be realized in production costs, while permitting up-grading to Class B (130°C) temperatures.

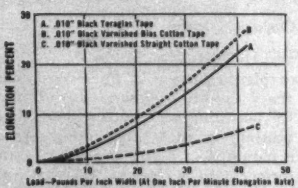
Natvar Teraglas is available in two thicknesses, .010" and .012"—in tapes, in full width rolls (36"), or in sheets. Ask for Data Sheet and Samples.

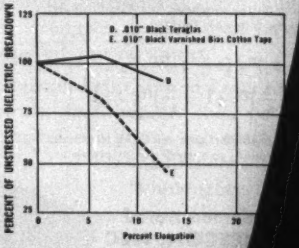
TYPICAL DATA

Physical Properties:		.010"	.012"
Approximate weight per sq. yd., lbs.		0.54	.62
Breaking Strength lbs./in. width,	Warp	45	45
	Filler	100	100
Tear Strength, grams	Warp	Over 1000	Over 1000
	Filler	Over 1000	Over 1000
Elongation, % (Under 25 lbs./in. width—3 minutes)		7.5	7.5

Electrical Properties:	.010"	.012"
Electric Breakdown Strength (C48-23-50 V/M)	1600	1600
Electric Breakdown Strength (Under 6% stretch)	1600	1600
Electric Breakdown Strength (Under 12% Stretch)	1450	1450
Power Factor, %, at 80° C-50 V/M-60 c.p.s.	2.5	2.5

LOAD-ELONGATION CHARACTERISTICS FOR NATVAR BLACK TERAGLAS


A. .010" Black Teraglas Tape
B. .010" Black Varnished Bias Cotton Tape
C. .010" Black Varnished Straight Cotton Tape
ELONGATION PERCENT
Load—Pounds Per Inch Width (At One Inch Per Minute Elongation Rate)


D. .010" Black Teraglas
E. .010" Black Varnished Bias Cotton Tape
PERCENT OF UNSTRESSED DIELECTRIC BREAKDOWN
Percent Elongation

*Trademark applied for.

Natvar Products

- Varnished cambric—sheet and tape
- Varnished canvas and duck—sheet and tape
- Varnished silk and special rayon—sheet and tape
- Varnished papers—rope and kraft—sheet and tape
- Varnished, silicone varnished and silicone rubber coated Fiberglas*—sheet and tape
- Slot cell combinations, Aboglas®
- Teraglas**
- Isoglas® sheet and tape
- Isolastane® sheet, tape, tubing and sleeving
- Vinyl coated and silicone rubber coated Fiberglas tubing and sleeving
- Extruded vinyl tubing and tape
- Styroflex® flexible polystyrene tape
- Extruded identification markers

*TM (Reg. U.S. Pat. Off.) OCF Corp.
**Trademark applied for.

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versatile tool for system design engineers

- Solves differential equations by ROOT LOCUS plots.
- Provides BODE phase and gain plots from system poles and zeros.
- Synthesizes compensation networks.
- Evaluates residues.
- Factors polynomials.
- Analyzes sampled data systems.
- Solves non-linear problems involving hysteresis or saturation by the describing function technique.
- Designs process control systems.
- Derives process transfer functions from power density spectra.
- Uses rapid, logical pole-zero programming.
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$$F = \pm K s^{n_0} (s - s_1)^{n_1} (s - s_2)^{n_2} (s - s_3)^{n_3} \ldots$$

or

$$F = \pm K s^{n_0} \left(1 - \frac{s}{s_1}\right)^{n_1} \left(1 - \frac{s}{s_2}\right)^{n_2} \left(1 - \frac{s}{s_3}\right)^{n_3} \ldots$$

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New & Improved Products

(Continued from page 10A)

Computer Printer-Plotter . . .

This remarkably fast output device will provide 300,000 points of data per minute from computer-processed magnetic tapes. For missile scientists it means an appreciable shortening of the time lag in getting flight test information translated from computer language into easy-to-read graphic output form. The system can plot up to 10 curves simultaneously on a 12-inch-wide continuous chart record while drawing its grid lines and printed annotations. As a straight printer it is capable of producing 90,000 magazine or direct mail address labels per hour. *Briggs Associates, Inc., Norristown, Pa.*

Improved Ceramic . . .

The result of two years' development, AlSiMag *243* is an improved Forsterite ceramic with low loss and high Te value. Used wherever high frequencies or sealing metals or glasses

is involved, the product has favorable thermal expansion characteristics and is finding many new uses, particularly in vacuum tube applications. *American Lava Corp., Manufacturers Rd., Chattanooga 5, Tenn.*

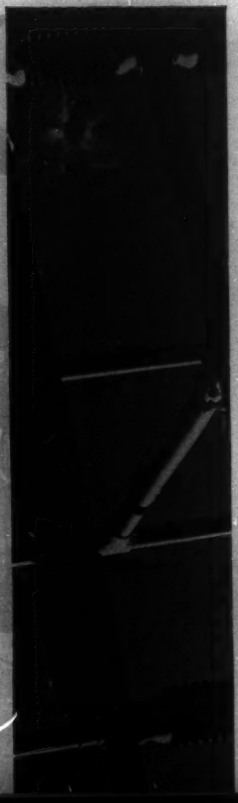
Outage Alarm . . .

Here is a radio system designed to identify a power outage or emergency condition along a utilities service network. A 25-watt remote alarm transmitter with tone coding device is mounted in a pressurized 3-kv transformer tank to insure operation regardless of weather. When a circuit breaker opens, the unit is triggered to generate a unique tone signal that is received in a central station for decoding. Utilizing the base station of any 25- to 50- or 150- to 174-mc two-way mobile radio system, as many as 290 remote points can be monitored at once. *Motorola Inc., Communications and Industrial Electronics Div., 4501 W. Augusta Blvd., Chicago 51, Ill.*

(Continued on page 18A)

Voltage Rating kv	BIL, kv	Cantilever Strengths lbs.		
7.5	95	2,000	4,000	8,000
15	110	2,000	4,000	8,000
23	150	2,000	4,000	8,000
34.5	200	2,000	4,000	8,000
46	250	2,000	4,000	8,000
69	350	1,500	4,000	6,000
115	550	1,700	2,900	4,000
138	650	1,450	2,450	3,900
161	750	1,200	2,000	3,500
	900	910	1,450	2,750
	1050	750	1,170	2,300
	1300		1,000	2,000
	1470		900	1,750
	1640		770	1,550
	1800		680	1,400

.....you can have what you want in BIL, in strength, in stiffness



Use of Lapp Station Posts frees designers of modern substations from the need to design around characteristics—and shortcomings—of conventional switch and bus insulators.

The family of Lapp Station Posts is a "modular series" which gives widest range of insulation levels *and* strength ratings. Station Posts are smaller in diameter, too . . . lighter in weight . . . stiffer . . . easier to assemble; and they're suited to mounting horizontally, underhung or angled . . . available in strengths greater than have ever been offered in conventional pin-cap units.

Stations on Lapp Station Posts require less real estate, less steel work. And, because their performance is better under all electrical conditions and mechanical loading, they need less maintenance too. You should have the whole story. You can read it in the new Lapp Catalog No. 8. If you haven't a copy, we'll be glad to send one.

Lapp Insulator Co., Inc., LeRoy, N. Y.

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Laminates - Custom Molding - Extruded Shapes - Channel Stock - Insulators

New & Improved Products

(Continued from page 12A)

Multitracer Storage Unit . . .

When used with the Memo-scope oscilloscope, the electronic multitracer will enable an operator to present and store consecutive sweeps at equal preselected intervals. Placed between the signal source and Memo-scope input, the unit becomes a combined attenuator, gate amplifier, and storage counter. *Hughes Aircraft Co., Florence Ave. & Teale St., Culver City, Calif.*

Core Tester . . .

This memory exerciser automatically locates and counts defects in a core memory system. One of a variety of checkerboard patterns is read into the memory, then read out and checked for accuracy. Cores that are dropping or picking up "ones" light an error bulb and are counted. The machine can either stop on the error to allow the operator to note the defects location, or it can pause on the error and then continue. *Digital Equipment Corp., Maynard, Mass.*

Portable Time Standard . . .

This lightweight self-powered unit was developed for use as a highly accurate time source and for precisely timing on-off control of recording and

telemetering equipment in remote locations. A 3-band transistor radio receives signals from a time-source broadcast station. A decoder in the radio circuitry synchronizes clock accuracy to ±16 seconds per year. *Zenith Radio Corp., 6001 West Dickens Ave., Chicago 39, Ill.*

(Continued on page 20A)

Side elevation of secondary bus system, using round tubular copper bus conductors, 2½" S.P.S., in unused plant tunnel. The run is approximately 275 feet long.

Round copper tube bus carries more amperes per pound of copper—cuts installation costs

When a large eastern electrolytic refinery recently shifted to purchased electric power, it capitalized on the electrical and mechanical advantages of round tubular copper bus conductors to effect some economies.

Directly below the 10,000 kv-a outdoor substation was an unused coal conveyor tunnel that ran some 275 feet back to the former powerhouse. In this, the secondary bus system using 2.3-kv high-conductivity bus tube, 2½" S.P.S., was installed as shown in the drawings.

These round conductors, having an extremely low skin-effect ratio (1.01) can carry well over 300 amperes per pound of copper—compared with less than 275 amperes per pound for rectangular bus of the same cross-sectional area.

In addition to this material saving, round conductors in standard pipe sizes made possible installation savings through the use of stock-size supports, connectors, and other hardware.

Substantial savings are often possible through the use of a tubular bus with a low wall-thickness-to-diameter ratio. More complete information on tubular conductors is available in the Sixth Edition of The American Brass Company's Publication C-25. This 62-page booklet has a wealth of general information on the properties of copper conductors—plus convenient data for the most commonly used sizes of all types of rigid bus conductors.

TECHNICAL SERVICES. Anaconda specialists are available to help you in the solution of technical problems involving the use of Anaconda Bus Conductors. For such service, or for a copy of Publication C-25, see your nearby Anaconda representative. Or write: The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass, Ltd., New Toronto, Ontario.

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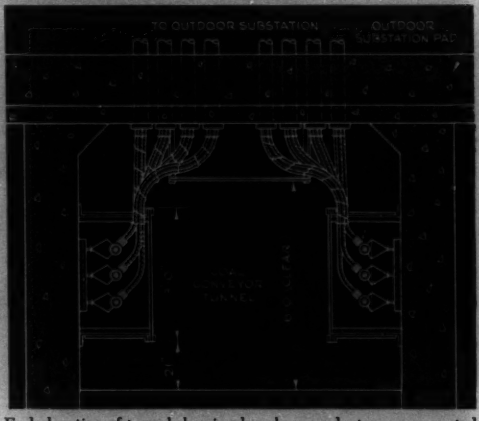

End elevation of tunnel showing how bus conductors are mounted on either wall, covered by a simple expanded metal enclosure.

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127 SUSSEX AVENUE
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Reliable Thyratrons

New & Improved Products

(Continued from page 18A)

CdS Transistor . . .

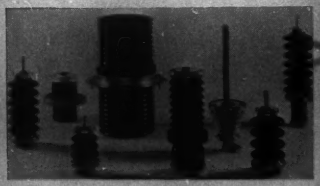
Although still experimental, a new cadmium sulfide field-effect transistor, believed to be the first of its kind, promises interesting applications as an oscillator, multivibrator, amplifier, and radiation detector. Because the electrical properties of cadmium sulfide are greatly affected by light and other radiation, these photoconducting properties make it a unique circuit device where amplification can be controlled by changing color or light intensity. *General Motors Corp., 1775 Broadway, New York 19, N.Y.*

Beat-Frequency Video Generator . . .

Suitable for point-to-point, transient, and sweep testing, this type *1300 A* generator can be used as a test source for acoustic and ultrasonic equipment, video systems, amplifiers, discriminators, networks, and for wide- and narrow-band video filters. Ranges are from 20 cps to 20 kc sine or square wave for audio and from 20 kc to 12 mc sine, and 20 kc to 2 mc square wave for video with a 60 cps sinusoidal sweep rate for the latter. *General Radio Co., West Concord, Mass.*

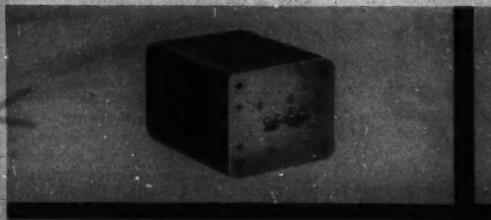
Solder-Seal Bushings . . .

Solder-seal bushings designed for low-voltage applications on hermetically sealed capacitors, test transformers, and similar types of electrical equipment have the advantage of being completely leak-proof, with high mechanical and dielectric strength. The bushings consist of a porcelain



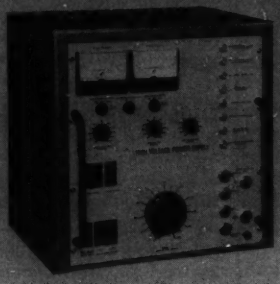
unit with a thin "fired-on" metal coating to which metal caps, flanges, and rings can be attached by soft solder techniques. The completed attachment is strong and permanent and will rupture the glaze from the porcelain before it will rip the metalized band from the glaze. *Lapp Insulator Co., Inc., Le Roy, N.Y.*

(Continued on page 22A)



Model QM6.3-.32. Miniature Transistorized Regulated D-C Supply features regulation to ±0.05% for combined line and load variations. This is one of more than 180 miniature component-type power packs offered by Sorensen. They include, in addition to highly regulated d-c supplies, dc-to-ac inverters and dc-to-dc converters.

Model Q12-15A. One of the 15 Sorensen Q Series high-precision transistorized low-voltage supplies, features voltage regulation to ±0.05% for combined line or load variations. Models for 6, 12, 28 vdc out, with power capacities up to approximately 240 watts. Similar QR Series features precision regulation with wide output voltage adjustment range. Two models: 0-75vdc at 2 amps max and 0-36vdc at 4 amps max.



Model 2150-5 (Control Section). This is just one of a tremendous variety of Sorensen high-voltage d-c supplies, high-voltage a-c and a-c/d-c testers, and electrostatic generators. Models completely cover the voltage range from 1000 to 600,000 volts. Power outputs range up to 60 kilowatts.

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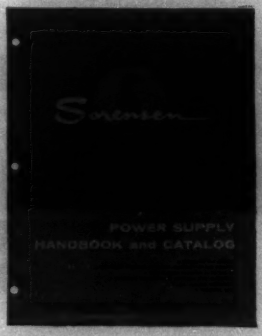

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...the widest line lets you make the wisest choice

NEED MOTOR CONTROL CENTERS QUICK?

QUICK SHIPMENTS

Nelson cuts delivery time 50%. Units assembled from off-the-shelf assemblies.

MANY COMPONENTS

Quick-trol units are available with comb. starters, switch or CB type, sizes 1-4 FVNR, sizes 1-3 reversing; Main or branch circ. breakers or fused switches; Lighting panels up to 24 circuits.

SAVES TIME

Quick and *easy* installation due to
- Big 35 sq. in. vertical wiring gutters
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QUALITY FEATURES

- Attractive, ruggedly constructed cubicles
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- Rigid 25,000 AIC bus bracing
- Reliable components throughout

NELSON *Electric* MANUFACTURING CO.
TULSA, OKLAHOMA

New & Improved Products

(Continued from page 20A)

Gas Turbine Power Unit . . .

This mobile tractor-trailer power unit is capable of producing 7,500 kva and has as its prime mover a lightweight aircraft-type gas generator coupled aerodynamically to a power turbine. As an emergency or auxiliary power source the unit operates on kerosene, diesel oil, gasoline, or JP 4/5 and can be transported with due

Courtesy General Electric

respect to Interstate Commerce Commission regulations at sustained speeds of 35 mph on highways. With a total weight of 95,000 pounds including turbine, generator, and switchgear the trailer unit can be easily airlifted in large military cargo aircraft for emergency operations. *General Electric Co., Schenectady 5, N.Y.*

Silicone Rubber Tape . . .

ES 5111 is a glass cloth tape coated with silicone rubber and is used to give armor protection when winding motor coils for low- or high-voltage units. A feature of this product is that one side is fully covered while the other is left uncovered permitting an unusually stable and long shelf life. It also provides a void-free envelope for rotating machinery coils without resorting to combinations of heat and pressure. *Permacel, New Brunswick, N.J.*

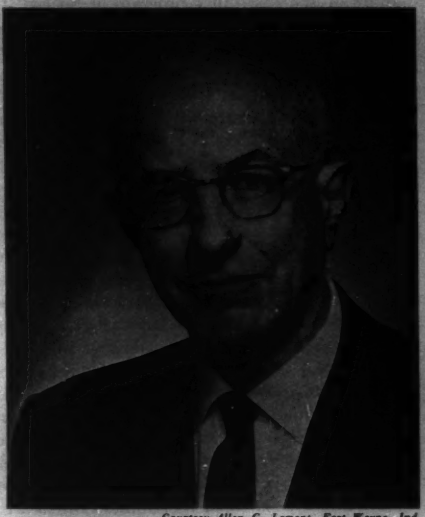
Business Computer . . .

Specifically designed for business routines, the newly developed solid-state IBM *7080* is ten times faster than the "old" IBM *705* that helped prepare its circuit designs. Major features include: a communication storage unit for transferring information between tapes and main data storage that is so fast that up to five tape units can be read simultaneously; a main memory unit of 160,000 characters with recall speed of 2.18 microseconds; a priority processing system that permits input/output devices to control the flow of programs automatically. *International Business Machines Corp., 112 E. Post Rd., White Plains, N.Y.*

(Continued on page 26A)

Beginning Our Fourth Quarter-Century

J. H. FOOTE
PRESIDENT AIEE



Courtesy Allen C. Lomont, Fort Wayne, Ind.

Our president, standing on the solid accomplishments of the past 75 years, looks confidently into an era of expanding boundaries and overlapping disciplines toward the centennial celebration of the Institute.

THE CLOSE of the Diamond Anniversary year of celebration presents to us the opportunity—yes, the obligation—to plan for a fourth quarter-century of accomplishment such as will justify a most glorious centennial celebration in the year 1984. An essential in such planning is an appraisal of the present situation upon which a program may be based and from which it shall proceed in dynamic fashion toward the attainment of a sound objective.

If there is one outstanding characteristic of the animus active in the life of the world's people today, it is that of realignment. Whether we consider politics or business, education or technology, or almost any element of the social structure, we find new objectives, new alignments, and new criteria demanded by the citizenry of the nations, organizations, and common-interest groups. This same characteristic—realignment of interests—is of genuine concern to the engineering societies, including our own Institute.

OVERLAPPING DISCIPLINES

LIFE IS NO LONGER SIMPLE nor is technology stably compartmented. The separate engineering disciplines are bursting at the boundaries. It is difficult today to contain in simple and definitive terms the scopes of interest and concern of the so-called disciplines encompassed by any founder society.

For example, mining engineering is now concerned not only with metallurgical but also with petroleum engineering; it is heavily involved with fans, pumps, machines, pipe lines, and a variety of electric power, communication, and control engineering that includes microwaves, computers, and electronic control systems.

Mechanical engineering not only is vitally concerned with rotating electric machinery but also with analyses of control systems and equipment that often render indistinguishable in content and presentation the technical papers of ASME (American Society of Mechanical Engineers) and AIEE authorship.

And when we assemble a team of scientists and engineers to develop and execute constructional designs for an atomic power plant, we discover such an overlapping of disciplines that engineers often may be assigned responsibility in a field nominally foreign to their historic alignment.

This disintegration of traditional boundaries extends from engineering into the fields of science. Recently, a director of important engineering work in the missile program expressed the view, based upon his recent experience, that specific educational preparation and background of experience, whether of science or of engineering, are not determinant in the choice of men for engineering positions of responsibility. If the man were good, he said, he would do well. And by good he implied possession of thorough understanding of the problems and of the resources which might effect a solution, together with the means of effectively marshaling all resources, including those residing in human personalities, which bear upon the problem.

At the same time we find general expression of a contrasting trait. We observe keen interest in those meetings and presentations which have to do with the particular engineering matters in which the engineer is currently involved. A program to satisfy such interests would seem to be in distinct contrast to that which nurtures the broad viewpoints of engineers in other fields and with broader responsibilities.

It is possible that a solution to this enigmatic situation is already under way. I wonder if we have been

Essentially full text of address presented at the general session of the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960.
J. H. Foote is chief engineer, Commonwealth Associates, Inc., Jackson, Mich.

aware of the Institute's program of Special Technical Conferences, more than half of which are held in collaboration with other societies having correlative scopes and interests. Each conference covers a single area of interest, usually with one but with not more than two parallel sessions and publishes the papers presented and discussed. Often there is an exhibit of pertinent apparatus.

SCOPE OF TECHNICAL CONFERENCES

THIS ADMINISTRATIVE YEAR there are 36 conferences scheduled from coast to coast. Some are sponsored by our Institute alone, but the majority are co-operatively sponsored with IRE (Institute of Radio Engineers), ASME, ASTM (American Society For Testing Materials), NEMA (National Electrical Manufacturers Association), ISA (Instrument Society of America), other societies, universities, and associations. Sometimes as many as five sponsors collaborate in one conference.

Your president has attended one or more sessions of 13 of the 17 Special Technical Conferences held thus far. While the National Electronics Conference in Chicago was a huge affair with 9,700 registrants, the typical conference drew attendances of 300 to 600 for 2 or 3 days. When the year's attendance is totaled, we may find that between 25,000 and 30,000 engineers, scientists, and students have attended these conferences, participated in technical presentations and discussions, viewed exhibits, and taken home papers and publications. What a service is being carried on!

Perhaps we have here an indication of the direction toward which we should turn in seeking to be more effective and attractive to members. The action of our Board of Directors at the Fall General Meeting in adopting recommendations formulating a special study committee point in this general direction. Implementation will follow, including more effective communications between technical groups in Sections and correlative technical committees.

It is gratifying to report that our newly constituted Intersociety Relations Committee is about to open discussions with the IRE concerning early formulation of a program of closer collaboration with IRE in the Student Branch area immediately, and in other areas in the early future.

Our Institute is continuing its efforts to develop more effective nation-wide channels of communication leading toward a feasible unity organization. We are encouraged, although it will take time to achieve results.

Thus, the problems facing AIEE parallel similar problems facing many other organizations in this day of realignments and fermenting interests and are of a kind with problems facing society at this time in widely diverse contexts.

We must view these problems objectively, looking for dynamic solutions which project out and beyond our past and present fine attainments.

Let us expand our view of the Institute's potentialities to include the requirements of the very considerable number of young engineers who will join us year by year during this Fourth Quarter until by 1984 they may constitute the working core of our membership.

Let us press forward with vigor to adopt new methods and facilities to serve better the membership's essential needs insofar as its expression of interest justifies the costs involved.

And at the same time may we have courage to adapt or to discard, if necessary, those facilities which have served well but which must be brought into tune with any determined realignment of our program.

Thus, we proceed with confident expectancy into the early years of this Fourth Quarter with the hope that each of its years may mark its score of progress and dynamic achievement.

Indoor Motor Runs Outdoors

Insulation advances have enabled engineers at Westinghouse's East Pittsburgh, Pa., plant to operate successfully a standard indoor-type motor out of doors. The motor, a drip-proof 500-hp 2,300-volt induction motor equipped with Thermalastic (registered trademark) insulation, has operated successfully for 2½ years through two complete winters. It has been exposed to a typical northeastern climate, including snow, sleet, rain, dust, and heat.

Periodic maintenance tests—including dielectric absorption studies at various voltages and a d-c overpotential test at the 6-kv level—have revealed no indication of any pending difficulty. Westinghouse plans to continue to operate the motor for an indefinite time.

Detector Car History and New Developments

H. W. KEEVIL

THE HISTORY of rail detector cars began about 1926 when the railroads were faced with a very serious safety problem. This problem was the development of a new type of defect that was causing many rails to break.

This failure was called a "transverse fissure" because it always developed in a transverse plane with respect to the length of the rail.

These defects were of such a serious nature that the Association of American Railroads (AAR) investigated all methods of testing to determine a way to detect them before they caused rail failures. One of the suggested methods of test was to pass a direct current, of several thousand amperes, through the rail and by means of small fixed contacts to pick off an *IR* drop. As long as these fixed contacts were on good rail, the *IR* drop remained constant; but if they bridged over a fissure, the *IR* drop would suddenly rise.

This method was checked in the laboratory and proved successful. The equipment was then mounted on a test car for progressively testing the track. On the car the method failed because it was difficult to get and maintain perfect pickup contact on the rail.

An inductive pickup, balanced against main current variations, was substituted for the contact pickup. This system was successful; therefore, a number of cars were built and used on the railroads.

In the meantime, the AAR developed the "residual magnetic" method of testing. This method eliminated the use of costly generator equipment which was required to produce the heavy rail currents. This reduced both the initial cost of the cars and the operating costs. A number of these cars were built for individual railroads.

The use of these various detector cars brought the rail failure problem under control.

The AAR, working with the rail manufacturers, determined the cause of the transverse fissure to be a shatter crack formed in the steel while cooling. The steel mills developed new cooling processes to eliminate the formation of these shatter cracks. This process has been most successful; thus eliminating the cause of transverse fissures.

This new rail did not reduce the need for regular testing because it will be many years before all of the older rail will be removed from track and there are other types of defects in both old and new rail that should be detected and removed before they cause rail failures.

The problem of testing the rails within the joint area has come up in the last few years. The electro-inductive method is poor in this area because the heavy rail current leaves the rail and travels through the joint bars. The residual magnetic method is more successful since it can detect defects in the head of the rail to within 3 inches of the end of each rail.

An ultrasonic method of detection has been in the process of development for several years. This method, at the present time, can detect horizontal and diagonal cracks that develop from the bolt holes in the joints. Work is being done to develop ultrasonic means for the detection of all types of defects regardless of where they are located in the rail. When this goal is achieved, the ultrasonic method may supersede the present methods of testing.

The German Federal Railway has developed and is using an ultrasonic detector car for the detection of all types of defects. This car can operate at a high rate of speed due to the photographic recording that it uses. There are several drawbacks to this type of recording such as the time delay of several days for processing and analyzing the tape before it is known whether there are any defects present. The need of locating a defective rail purely from identification marks that were put on the tape during the test requires very accurate tie-in points on both track and tape.

There are so many groups now working on this development that it should not be long before some major improvements are made in both test equipment and testing techniques.

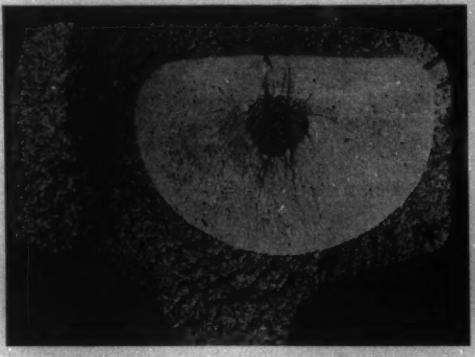


Fig. 1. Transverse fissure.

Digest of paper 59-267, recommended by the AIEE Land Transportation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE-ASME Railroad Conference, Chicago, Ill., April 7-9, 1959. Published in AIEE *Applications and Industry*, Sept. 1959, pp. 233-39.

H. W. Keevil is with the Association of American Railroads, Chicago, Ill.

Russian Power Development
and Some Implications for the United States

C. E. EBLE

An over-all picture of Soviet power development is presented by the author, who recently took part in a tour of power installations in the Soviet Union. The rapid development of Soviet engineering talent has been basic to their progress, and the continued development of American engineering talent is equally basic to our own progress.

IT IS IMPOSSIBLE to talk about engineering these days without taking into account the valuable contributions the profession has made to the industrial, technical, and scientific progress of our country. And significantly, these advancements have been far more than laboratory curios. Thanks to our ability to grasp and apply new ideas, we have developed the highest standard of living of any nation and established our pre-eminence as a world power.

Fundamental to our accomplishments is the free enterprise system. The tremendous gains we have achieved for the benefit of our people under this system testify to its validity and superiority over any other devised in the history of mankind.

SOVIET ADVANCES

IN A COUNTRY halfway around the world, however, some startling industrial and technical advances have been made under a system which is totally controlled and directed by the state. I refer, of course, to the Soviet Union, where essentially all industry is owned and operated by the state, and where the idea of any individual or corporate enterprise is unthinkable.

Last summer, I had the interesting experience of visiting the Soviet Union with a group of electric power people from this country and seeing first hand their progress in the electric power field—a field that is basic to all industry. Our trip, the second of this nature, was arranged by the U. S. State Department as part of the technical and cultural exchange program that has been established between the USSR and the United States. The idea of these exchanges seems to be that if groups of people from one country visit the other, the resulting contacts will lead to better understanding. I believe these exchanges are serving this purpose.

I would like to report on some of the things we saw on our trip, the impressions we gained, and certain of the implications I feel their power development holds for us. Please remember that I do not claim membership in the swelling ranks of the group in this country professing to be experts on the Soviet Union by virtue of a quick visit to that enigmatic nation. It would certainly take a lot more than an 11,000-mile 2-week tour of power installations in Siberia to be considered any kind of an expert. However, I do feel our group got an objective view of the status of electric power development in the Soviet Union and it is this picture I hope to present at this time.

Our host last summer was the Ministry of Construction of Power Stations. Throughout our visit, we found the Russians we met to be friendly, courteous, and hospitable. They appeared to be highly competent and firmly dedicated. They did not try to hide anything from us and we were not limited to any section of town or to any part of an area we visited. They appeared genuinely eager and sincere in their efforts to give us information about the Soviet electric power industry. We gained the strong impression that they were anxious to obtain similar information about our power systems and manufacturing facilities.

In our tour, we visited a number of the major hydroelectric, thermal, and atomic installations in Siberia. During the previous year, a group similar to ours toured installations in the European section of the Soviet Union.

It has been said that the Soviet Union is a land of paradoxes. I would certainly agree. Our group would fly for hours in a modern Russian turbojet plane and then land on an airfield without paved runways. We would then get into a well-made Russian automobile and ride miles over unbelievably rough roads to the nearest town.

One of the most difficult concepts for the first-time visitor to the Soviet Union to comprehend is the huge size of the country. It comprises almost one sixth of the land mass of the world, and its nearly 9 million square miles make it three times as large as the continental United States. One leg of our tour, for example, was from Moscow—already several hundred miles inside the Soviet Union—to Irkutsk, which is just about halfway across the country. This was a 3,300-mile flight, considerably farther than the distance from New York to Los Angeles.

The vast size of the country alone complicates the job of supplying power, and it is not surprising that many tremendous areas in the Soviet Union do not have electric service. The power problems created by geography

Essentially full text of an address presented at the general session of the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960.

C. E. Eble is president, Consolidated Edison Company of New York, Inc., New York, N. Y.

have also had their effect on the location of cities and industry. Many large hydro sites, for example, are far from historic Soviet population centers. To take advantage of these power resources and at the same time achieve greater decentralization of industry, the Russians have built entire cities around heavy industry in certain parts of Siberia. The town of Novosibirsk, which in the 1920's was little more than a whistle stop on the Trans-Siberian Railroad, now boasts a million people and is a great industrial center.

In talking about Soviet power development, I would like to give an over-all picture of the situation, some brief comments on the status of generation and transmission, and some facts on how the power is being used there.

CAPACITY

IN TERMS OF TOTAL CAPACITY, the Soviet power industry ranked second in the world at the end of 1958 with a reported 53 million kw. This compares with 160 million kw of capacity in the United States at the same time. The USSR's position in world power supply is not surprising, in view of its great size, its enormous natural resources, and its vigorous determination to carry out industrialization of the country as rapidly as possible.

The latest Soviet Seven Year Plan calls for installation of some 60 million kw of capacity between 1959 and 1965, bringing the total then to about 113 million kw. According to reliable forecasts, the United States will have 250 million kw by 1965. Thus, the gap between United States and Soviet power capacities which was 107 million kw in 1958 will have increased to about 137 million by 1965.

In 1958, 80% of their power was produced by thermal stations and 20% by hydro—about the same ratio as in our country. Their new Seven Year Plan, however, places decreased emphasis on hydro and more on thermal despite the fact that they have tremendous amounts of undeveloped hydro capacity. During this period, about 85% of new capacity will be thermal.

In a 1958 address, Premier Khrushchev announced this shift and gave as reasons the fact that hydroelectric plants are more expensive and take longer to build. The Russians have apparently come to the same conclusions reached in this country many years ago; namely, that only under favorable conditions is hydro power more economic than thermal power.

In terms of hydro resources, the USSR has over three times as much potential capacity as the United States. Four fifths of it, however, is in Siberia. Certain of their hydro sites are beyond anything we have here. For example, we visited the Bratsk hydro plant, now under construction in Siberia, which will have a capacity of 4.5 million kw. The largest developed hydro site in the United States—Grand Coulee—has less than half that capacity. This, however, is primarily a function of geography, not of technical skills. The Russians appear to be able dam builders and have developed a number of interesting construction techniques. However, I do not believe we saw anything that would indicate that Russian hydro technology is more advanced than ours.

In the steam generation of power, the Soviet Union appears to lag well behind the United States. In 1957, they had only three units of 150,000-kw size in operation. The first units of this size installed in the United States went into operation in the late 1920's. We now have a number of units in operation with capacities greater than 300,000 kw. And United States manufacturers are now building several units between 400,000 and 600,000 kw in size. When it comes to units of this size, the Russians are barely in the design stage.

Like us, the Soviets are using steam with high initial pressures and temperatures to make their plants more economical. However, the temperatures and pressures used in practically all of their modern units are well below those used in modern units in this country. The Soviet plants cannot help but suffer relatively in efficiency. For some of the large units being designed, the Russians are planning to use supercritical-pressure steam. The pressures and temperatures to be used in these units will fall in the same general range as those of the supercritical-pressure units now operating in this country. We learned that in the larger, more efficient plants in the Soviet Union, between 2 and 2.5 persons per 1,000 kw of capacity are required to operate the plant. Here it takes between 0.2 and 0.5 persons—about one tenth of the Soviet personnel requirements.

NUCLEAR POWER

THE ATOMIC POWER program in the Soviet Union is still in the research and development stage, just as it is in this country. Experimental work with various types of reactors is being carried on in an attempt to develop methods of producing electricity from atomic energy as economically as from conventional fuels. As we do, the Russians expect the cost of producing power from atomic fuels to be higher than from conventional fuels in the early atomic plants. Accordingly, they do not plan any large-scale development of atomic power until it becomes economical. They now have a 5,000-kw and a 100,000-kw plant in operation. They have three under construction, two of which we visited. By comparison, we have three plants in operation, 14 scheduled for completion between now and the end of 1963, and several more planned. The Russians share our belief that ultimately a way will be found to generate power economically from nuclear fuels.

HIGH-VOLTAGE TRANSMISSION

FROM A TECHNICAL STANDPOINT, some of the most interesting work going on in the Soviet Union today is in the field of high-voltage transmission. The developments in this field would seem to have been demanded by the Soviet Union's historic emphasis on the development of hydro. With hydro sites located far from the chief industrial centers in European Russia, long-distance high-voltage transmission became a necessity.

In 1958, some 2,600 miles of lines were operating at 400,000 volts and the construction of an 800,000-volt direct-current line from the Stalingrad hydro station to the Don Basin—some 300 miles—is expected to be completed in 1962. Some of the 400,000-volt lines are scheduled to be converted to 500,000 volts in the near future.

Russian historic preoccupation with hydro has led to some strange situations. For example, over a million kw of Moscow's power supply comes from the new Kuibyshev dam, 600 miles away. This is like generating electricity in South Carolina to supply New York. However, the Russians have not been influenced in their economic thinking by such significant factors as charges of interest on funds invested in plant. This has led to their undertaking certain projects which, in our terms, would be woefully uneconomic.

In the United States, the highest-voltage transmission lines now in operation are 345,000 volts. The next higher step will probably be 460,000 or 500,000 volts. Tests are under way in this country on 500,000 and 750,000-volt lines.

At the end of 1957, the total length of transmission lines in the USSR of 35,000 volts or more was said to be 62,000 miles. In contrast, we then had 240,000 miles of such transmission. With the Soviet Union three times as large in area as the United States, the magnitude of their electrification job ahead becomes apparent.

ELECTRICAL CONSUMPTION

In the use of electricity, the United States and the Soviet Union are at perhaps the widest variance. Our country is just about completely electrified. We have an abundance of power. The uses of electricity here are determined by our people in accordance with their needs. And our people have the purchasing power not only to buy electricity but also to supply their homes, farms, and shops with all kinds of electric appliances. The end result of this is that we have a very large home, farm, and commercial use in addition to our heavy industrial consumption.

The Soviet Union, on the other hand, has been and is today a relatively undeveloped nation. Vast areas today do not have electric service. As a totalitarian state with a vigorous determination to industrialize, the Soviet Union for many years has placed primary emphasis on the development of heavy industry at the expense of other aspects of the economy. This is evident from the fact that 80% of Soviet power goes for industry, and a mere 20% for residential, farm, and all other uses. Average home use is 400 kwhr per year, as against our 3,400.

While the Soviet planners can readily bring about increases in industrial use of electricity through plant expansion, they cannot do the same for home consumption. The use of electricity in the home depends in large measure on the purchasing power of the people—the purchasing power to buy appliances as well as electricity. In the Soviet Union, it also depends on the willingness of the state to devote a greater part of its productive capacity to making such consumer goods. Increased home use will come about only with an increased standard of living, and this is something that cannot be accomplished overnight. Although we were told of Soviet plans to continue to emphasize heavy industry, we heard of no plans to promote the increased use of electricity for commercial establishments, for the home, or for the farm.

Looking back over our trip, I think we can be comforted by the substantial qualitative and quantitative lead we hold in this vital industrial area. On the other hand, I saw nothing that would encourage complacency on our part.

When you consider that the pre-World War II Russian economy was, according to the economists, about 40 years behind our own at that time, there is no question but that the Soviet Union has made astonishing progress in power development in the last few years. Incredible difficulties in this field are being overcome: vast distances, huge undeveloped areas, an almost complete lack of mass technological training, plus, of course, the terrible devastation wreaked upon the nation by World War II. Their progress is continuing at an admirable rate and, in all probability, their industrial plant will continue to develop as their supporting base of electric power supply grows.

I would like to inject a thought here on this matter of whether we are ahead of the Russians in this field or that. To be sure, we are concerned with maintaining our over-all industrial leadership. We have done this in competition with nations throughout the world for years. In terms of electric power supply, however, I think the important leadership we must maintain is technological. If we continue to supply all the electricity we need by the most efficient and economic means, this will work to the competitive advantage of American industry in world markets in the future, just as it has in the past.

It is in the area of technology that I see the greatest challenge to our power industry from the Soviet Union in the decades ahead. One of the things that impressed me greatly everywhere we went in the Soviet Union was the dedication, enthusiasm, and competence displayed by the people handling the engineering, operation, and construction at the various establishments we visited. And the mere size, complexity, and number of the projects we saw indicated the wealth of engineering and technical talent that has been brought to bear on this basic phase of their industrial activity.

ENGINEERING MANPOWER

Where did all this talent spring from? Before World War II, engineering and technical talent of any description in the Soviet Union was a rare commodity. But in 20 short years, literally a generation of competent, enthusiastic young engineers seems to have been produced. And a great number of these engineers have obviously been placed in the electric power field. Of course, in a totalitarian state, you can make some things happen

whether the people involved like it or not. You can crank out thousands of engineers, artists, or butterfly collectors if you wish. Interestingly enough, they have employed incentives which make it so desirable to be an engineer that there are thousands more candidates than could possibly be used. They have glamorized the profession. They pay high rates for engineering talent in terms of money and preferential treatment. They completely finance the education and training of those young people qualified and selected for engineering careers. As a result of all this, the engineer has a definite high status in Soviet society with benefits far beyond those of the bulk of Russian people. They are obviously building for both the present and the future by creating a vast pool of engineering talent.

Our ability to meet the Soviet challenges in the electric power field, as in other fields, hinges importantly on our continuing success in developing new engineering talent. In a free society, we cannot direct people into the engineering field. Similarly, when people enter this field, we cannot direct that they become chemical, or electrical, or civil, or mechanical engineers. Nor can we direct that they go into this industry or that industry. In our competition with a totalitarian state, this might seem a big handicap, particularly in view of the relatively pat solution the Soviet Union has to this problem. In my mind, however, this is not a handicap, but the source of our strength. We have grown to greatness because our system is based on freedom of the individual, and this freedom has served to bring out man's finest efforts. It is gratifying to note the increasing attention being given by industry, by professional groups, by educational institutions, and by others to the pressing problem of attracting and developing talent in the engineering field.

In the electric power field, the problem of attracting a reasonable share of the highly competent young engineers has been increasing. Unless it is solved, where can we expect to find the kind of engineering leadership that will enable us to maintain our technical preeminence in this field? And I should add that the solution of this problem is of concern not only to the interests of our industry, but to the national interest as well.

To be sure, the so-called glamour industries—electronics, rocketry, and the like—will rightly continue to appeal to many of our brightest engineering graduates. But our industry is confronting technical challenges today that are no less formidable than those of the glamour industries. I have heard some badly informed opinions to the effect that the power industry has solved all its technical problems and it is just a matter of doing the same thing over and over again to keep up with growth. The challenges ahead for our industry in nuclear energy, higher-voltage transmission, direct conversion of heat into electricity, thermonuclear power, and solar energy call for technical competence of the highest order. Clearly, our industry has not done the job of selling itself well enough to engineering students. It is a job we must do better in the future. It is also one in which engineering societies, who have a vital concern in the nation's engineering manpower situation, can make important contributions.

CONCLUSION

As I EXAMINE the over-all picture of Soviet power development, there is no doubt in my mind that the Russians are competent, enthusiastic, and purposeful. They are intent on surpassing us in industrial capability, and electric power is fundamental to this capability. However, I am firmly convinced of the inherent strength of our free enterprise system, and I do not think the Soviet Union will overtake us at all unless there is a radical change in our respective systems. If that nation adopted the incentives and rewards of free enterprise and we abandoned them, then this might come about. But make no mistake about this. The competition between the United States and the USSR in the years ahead will be rigorous, and the worst mistake we could make would be to underestimate Soviet capabilities.

Telescope Swivel Seat

This giant steel forging being machined at the United States Steel Corporation's Homestead Works will soon help man peer farther into outer space than he ever has before. The 27-ton ring stands almost 6 feet high and measures 10 feet across on the inside. Despite its size, it must be finished with jewel-like precision, inasmuch as it will be the inner spherical seat of the main bearing on which the world's largest radio telescope will revolve. The $79 million telescope is now being built for the U. S. Navy near Sugar Grove, W. Va. When fabrication and construction are completed, the unit will allow Navy scientists to "see" and "hear" objects in space up to 38 billion light-years away.

Tunnel Diode Operation and Application

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The tunnel diode offers significant physical and electrical advantages over conventional semiconductor devices. Its impact on future transistor technology is evaluated in the light of these advantages.

THE tunnel diode[1,2,3] consists of a p-n junction, with an electrode connected to each region, and is similar in construction to other semiconductor diodes used for such various purposes as rectification, mixing, switching, parametric amplification, and voltage reference. In each of the latter cases, the diode characteristics are optimized for a particular use by controlling the p-n junction geometry as well as the physical parameters of the semiconductor material that is used. The tunnel diode, designated P_TN, requires two characteristics of its p-n junction: that it be narrow (i.e. the chemical transition from n-type to p-type regions must be abrupt), of the order of 100 Angstrom units in thickness, and that both regions be degenerate (i.e contain very large impurity concentrations, of the order of 10^{19} per cubic centimeter).

OPERATION AND PROPERTIES

THE LOW-FREQUENCY CHARACTERISTIC of a typical germanium tunnel diode is shown in Fig. 1a for a forward bias (p-type region positive) and a negative bias. It differs from that of any other type of p-n junction diode in that a "spike" of current exists in the very-low-voltage region, giving rise to a negative resistance. The current scale may be changed, for example, by varying the p-n junction area. Tunnel diodes have been made with peak currents from 10 microamperes to 10 amperes. However, for a given semiconductor material, the voltage scale must remain, to a large extent, fixed. Hence, the tunnel diode is a low-voltage device, the power range of which can be extended only by increasing its current.

In order to establish a bias point in the negative resistance region, which is required in order to trace out the curve of Fig. 1a, the series load resistor must be less than the absolute value of the negative resistance. If the load resistor is too large, switching will occur and the negative conductance region of the *I-V* curve will not be seen. If the load resistor is smaller than the negative resistance, but the circuit inductance in series with the tunnel diode is not negligible, the device may oscillate at a frequency so high that the oscilloscope cannot follow it. This results in a scope trace like that shown in Fig. 1b, the distortion in the negative conductance region indicating the presence of oscillation.

The high-current density at low voltages, both forward and reverse, (Fig. 1a), is carried by electrons that travel across the p-n barrier by quantum mechanical tunneling. This effect is important in the realm of atomic physics, but it is nowhere so simply applied or measured as in the case of the tunnel diode. Quantum mechanical tunneling may here be visualized simply as the appearance of electrons on the opposite side of a p-n junction from the side where they originated, and at the same energy level, just as though they had tunneled through a barrier that they could not have surmounted. A simple band picture for the tunnel diode under various bias conditions is shown in Fig. 2. Only the degenerate valence band on the p-type side and conduction band on the n-type side are illustrated. Fig. 2a is the equilibrium case. On each side of the junction are drawn two curves. The cross-hatched one is the density of states occupied by electrons, the clear one is the density of unoccupied states. Their sum is the total density of states, shown as a dashed line. For quantum mechanical tunneling of electrons across the barrier to occur, there must be empty states at the same energy on the other side of the barrier into which they can go. Hence the need for degeneracy of both n-type and p-type regions. The junction must be thin so that the tunneling probability will be high.

The relative currents for different biases can be qualitatively seen by inspection of Fig. 2. Where there is a condition under which a large density of filled states is at the same general energy as a large density of empty states, the tunneling from filled to empty states will be large. For zero bias there must be zero current (Fig. 2a); so tunneling currents in both directions are equal. For a reverse bias (Fig. 2b) it can be seen that a very large electron current will flow to the right, a very small one to the left. Fig. 2c shows the band scheme for a slight forward bias and illustrates how the electron current from right to left is much larger than that flowing in the opposite direction. For a somewhat larger forward bias (Fig. 2d), currents in both directions are reduced, but

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the electron flow from n-type to p-type is still the larger. In Fig. 2e, the forward bias is equal to the sum of the degeneracies, the bands are "uncrossed," and no tunnel current can flow. Theoretically, using idealized models, the tunnel current should drop to zero at this point. Actually, it falls only to some intermediate level which is called, for lack of better understanding, the "excess current." As the voltage is increased still further, the injection current that is normally associated with all forward biased p-n junction diodes becomes dominating, increasing in a somewhat exponential manner with voltage (Fig. 2f). The tunnel, excess, and injection current regions in a tunnel diode characteristic are sketched schematically in Fig. 1a.

If the impurity concentration on one (or both) sides of the p-n junction is lowered, then one reaches a point where a negative resistance does not occur. Instead, the forward characteristic looks like that of a normal diode, with the exception that excess current often exists. For a reverse bias, however, appreciable tunneling can occur (if the junction is sufficiently narrow). The resulting device is a "backward diode," since more current flows at a given "reverse" bias than at the same "forward" bias. Charactertistics of a backward diode are shown in Fig. 3. Since tunnel current does not produce injection modulation of resistivity, a current exists at which "forward" and "reverse" voltages are equal. At still higher currents, rectification is in the direction normal to a p-n junction rectifier.

Since its characteristic is everywhere so conductive, and since its structure contains at all places such large impurity concentrations, the tunnel diode is notably less sensitive to surface effects than other semiconductor devices. This results in a device so stable that operation in an unencapsulated state is possible even under rather severe moisture and contamination conditions. However, if the shunting conductance becomes so large as to be comparable to the diode negative conductance, the apparent characteristic becomes distorted. The tunneling of electrons across a p-n barrier does not depend upon minority carrier lifetime in the semiconductor material. For this reason the tunnel diode is much more tolerant to nuclear radiation than other p-n junction devices. Germanium units have survived 10^{14} n.v.t. (neutrons per square centimeter) neutron dosage with very little or no change in characteristics, and it is expected that much higher doses will be tolerated before appreciable changes occur. Also, because the tunnel diode characteristic is so highly conductive and because low lifetime material can be (and generally is) used, ionizing radiation such as light has very little effect.

Table I. Properties of Tunnel Diodes Made from Various Semiconductor Materials

Semiconductor Material	Tunnel Diode Characteristics			
	I_p/I_v at 30 C	V_v my	T_{max} (C)	$\frac{1}{R_j C_j}$
Ge	15	450	300	5×10^9
Si	4	700	400	5×10^9
InSb*	10	200	25	2×10^{11}
GaSb	20	450	300	10^{10}
GaAs	40	1,000	**	10^{10}

* at —200 C.
** Undetermined, but possibly as high as 600 C.

The Fermi level is within the conduction band in degenerate n-type semiconductors, within the valence band in degenerate p-type semiconductors. (cf. Fig. 2). Hence, the "overlapping" band structure of a tunnel p-n junction should persist even down to absolute zero. This permits tunnel diodes to work in the liquid helium temperature range. Also, tunneling continues at high temperatures, so that the negative resistance region persists until a point is reached at which the forward injection current becomes appreciable at low voltages, and effectively adds a positive shunt conductance equal to the negative conductance. Temperature characteristics for a germanium device are shown in Fig. 4. A silicon tunnel diode maintains its negative resistance up to a temperature in excess of 400 C. An interesting change in the characteristics of tunnel diodes, especially those made of silicon, occurs near the origin at very low temperatures.[4] It has been interpreted as being due to the effects of phonons on the tunneling process (Fig. 5).

Tunnel diodes have been made from a number of semiconductor materials.[5,6] Table I lists five of them, together with some of the device properties that have been obtained. T_{max} is the temperature at which the negative resistance disappears.

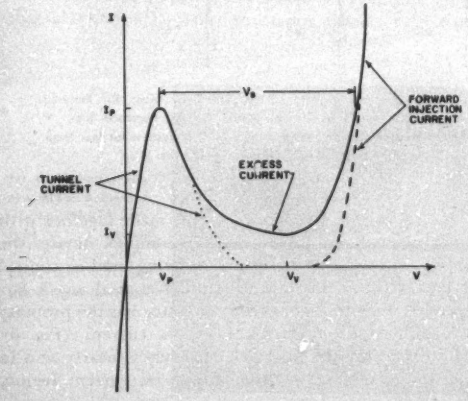


Fig. 1a (*left*). Static characteristic of a tunnel diode showing the three regions. Fig. 1b (*right*). Apparent static characteristic of a tunnel diode showing the presence of oscillation. There are 0.2 ma (milliampere) per division vertically, 0.1 volt per division horizontally. Germanium unit.

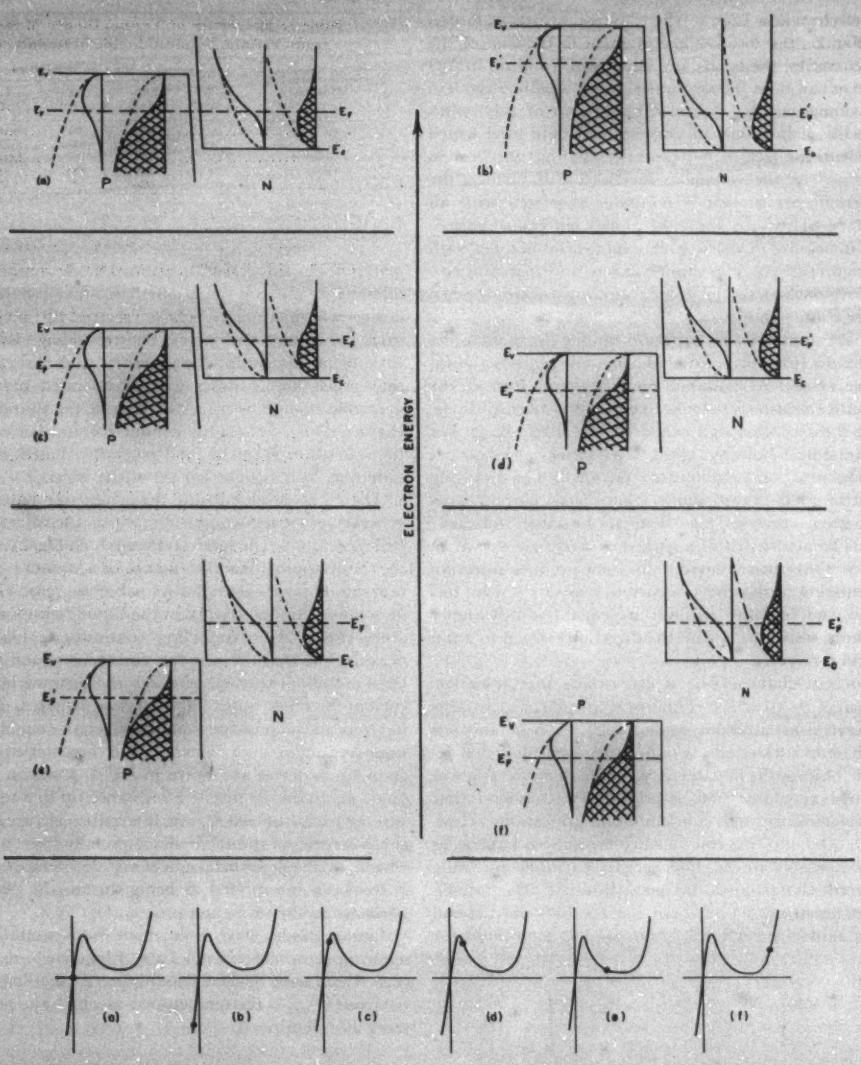


Fig. 2. Band picture of the tunnel diode as a function of bias. Only the p-type valance band and the n-type conduction band are shown. Densities of filled states are plotted cross-hatched, densities of empty states are plotted clear. Total densities of states are given by the dashed curves. (a) Zero bias; (b) Reverse bias; (c) Forward bias, V less than V_p; (d) Forward bias, V slightly greater than V_p; (e) Forward bias, V somewhat less than V_v; (f) Forward bias, V somewhat greater than V_v.

The noise generated by a tunnel diode[7,8,9] has been shown, for germanium devices in the negative resistance region, to be close to the full shot noise associated with the current that is flowing. Sometimes noise in addition to shot noise is present in the valley region. At voltages less than the peak, the shot noise is that associated with the sum of the separate tunnel currents and hence does not drop to zero at zero current.

A P_TN (tunnel) junction may be made together with other normal p-n junctions in a complex device, the properties of the tunnel junction being used to control certain of the characteristics of the over-all device[10]. For example, a germanium P_TNP transistor has the property of common-emitter current gain vs. current (Fig. 6). This is because the injection efficiency is nearly zero in the tunnel region, small in the excess current region,

and increasing in the injection region. The high impedance of the collector junction in series with the P_TN emitter forces the emitter voltage to jump at peak and valley points, changing its character each time. This effect may be utilized in a germanium P_TNPN switch to produce characteristics that are more stable with temperature (Fig. 7).

NEGATIVE RESISTANCE CHARACTERISTICS

A GREAT VARIETY of electronic devices and circuits exhibit negative resistance characteristics; i.e., regenerative properties at zero frequency. It has long been known that such negative resistance characteristics may have one of two forms (Fig. 8). [11, 12] The *N*-type negative resistance, which is referred to as open-circuit stable (or short-circuit unstable, or current controlled) is characterized by zero-resistance turning points; the *S*-type negative resistance, which is referred to as short-circuit stable (or open-circuit unstable, or voltage controlled) is the dual of the *N*-type and is characterized by zero-conductance turning points. The thyratron and dynatron are vacuum-tube examples of devices which exhibit respectively *N*- and *S*-type negative resistance characteristics. Some 3-terminal devices may exhibit both an *N*- or an S-type characteristic, depending upon which two terminals are selected as the driving port. For example, the complementary transistor cascade in Fig. 8, which is the circuit equivalent of a hook-collector transistor, shows an *N*-type characteristic when viewed from one set of terminals (series-feedback configuration) but exhibits an *S*-type characteristic when viewed from a second set of terminals (parallel-feedback configuration). Two-terminal regenerative devices, such as the p-n-p-n diode or the tunnel diode, exhibit either an *N*- or *S*-type negative resistance depending upon the internal regenerative mechanism.

All practical devices are band limited by internal carrier dispersion effects associated with charge storage properties. The simplest lumped-parameter first-order approximations of such energy storage or dispersion effects may be represented by a series or parallel combination of a resistor and capacitor or by a series or parallel combination of a resistor and inductor. It can be shown that all *N*-type negative resistance devices or circuits

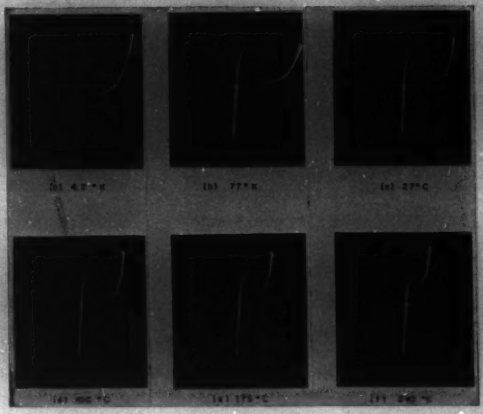


Fig. 4. Germanium tunnel diode temperature characteristics. There are 2 ma per division vertically; 0.1 volt per division horizontally. In (a), only the forward trace is shown, and the origin is shifted.

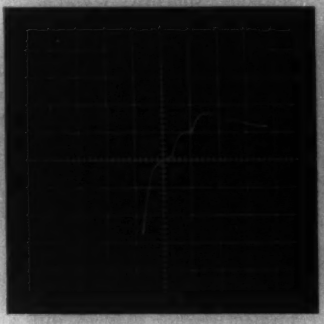


Fig. 5. Low-voltage characteristic of silicon tunnel diode in liquid helium. There are 0.05 ma per division vertically; and 0.05 volt per division horizontally.

Fig. 3. Characteristics of a silicon backward diode. There are 0.01, 0.1, 1, 10 ma per division vertically; and 0.2 volt per division horizontally.

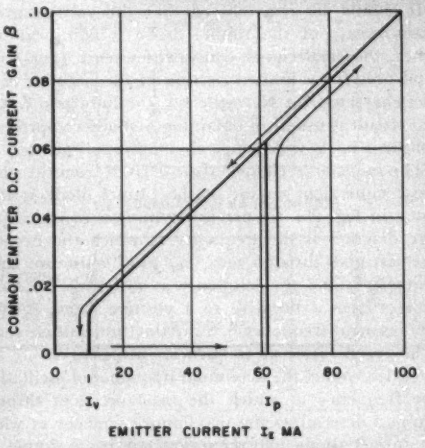


Fig. 6. Common emitter current gain vs. emitter current for a germanium P_TNP transistor.

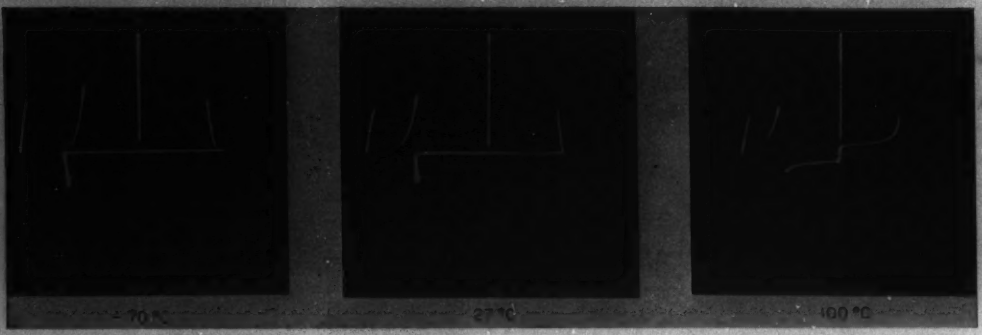


Fig. 7. Germanium P_1NPN switch characteristics, with tunnel emitter characteristic at left. There are 10 ma per division vertically; 10 volts per division horizontally, P_1NPN trace; 0.2 volt per division horizontally, P_1N trace. *Left*, –70 C; *center*, 27 C; *right*, 100 C.

may be characterized over a small portion of the negative resistance region, to a first approximation, by a series combination of a negative resistance and positive inductance; similarly, *S*-type devices may be approximated by a parallel combination of a negative resistor and positive capacitor.[12,13] These equivalent circuits determine how the device may be used in such applications as relaxation oscillators and tuned amplifiers and in addition determine the frequency limitations associated with the regenerative properties of the device.

Since the tunnel diode exhibits an *S*-type negative resistance, it may be represented "intrinsically" by an equivalent circuit which consists of a negative resistance in parallel with a capacitor (Fig. 9a). However, "parasitic" effects due to semiconductor body resistance and connecting leads are also significant in determining the higher frequency response characteristics; hence, an equivalent resistor in series with an inductance must be added to the equivalent circuit for completeness.

It should be remembered that the voltage-current characteristic of the tunnel diode is nonlinear and, hence, the small-signal equivalent circuit (Fig. 9a) is valid only for a limited portion of the negative resistance characteristic. Nevertheless, the linearized equivalent circuit is useful in obtaining first-order approximations in a fairly wide range of circuit applications.

The impedance characteristic derived from the small-signal equivalent circuit of the tunnel diode is illustrated in Fig. 9b). Of particular interest in the impedance diagram is the frequency at which the negative real part goes through zero, ω_R, (the "resistance cutoff frequency") and the frequency at which the reactance changes from a negative to a positive value, ω_s (the "self-resonant frequency"). Since the tunnel diode ceases to be regenerative at frequencies in excess of ω_R, the latter determines the maximum frequency of oscillation. The frequency at which the reactance goes through zero (ω_s) determines the maximum frequency at which the tunnel diode may be resonated by a simple inductor connected across its terminals and hence determines the maximum frequency of relaxation oscillation, if ω_s is less than ω_R. From the equivalent circuit illustrated in Fig. 9b, ω_R and ω_s can readily be calculated:

$$\omega_R = \frac{1}{R_1 C_1}\sqrt{\frac{R_1 - R_s}{R_s}} \tag{1}$$

$$\omega_s = \frac{1}{R_1 C_1}\sqrt{\frac{R_s^2 C_1}{L_s} - 1} \tag{2}$$

It is apparent from equations 1 and 2 that in order to obtain a high-frequency tunnel diode it is necessary

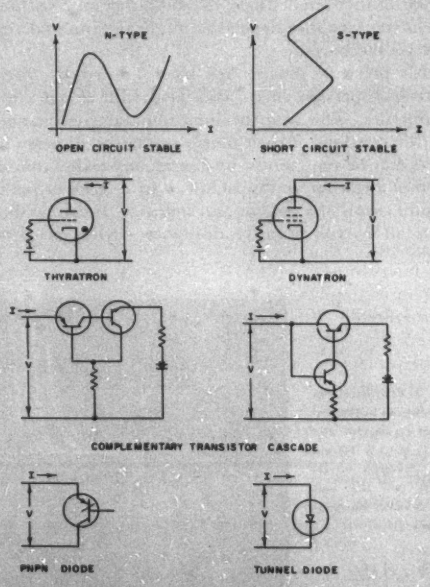
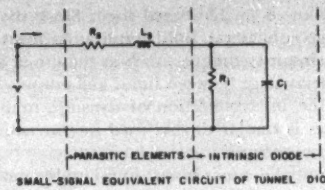
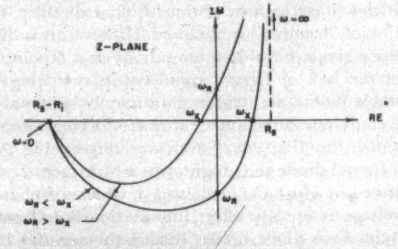


Fig. 8. Negative resistance characteristics and circuits.



(A) SMALL-SIGNAL EQUIVALENT CIRCUIT OF TUNNEL DIODE



(B) IMPEDANCE CHARACTERISTIC OF TUNNEL DIODE

Fig. 9. Small-signal equivalent circuit and impedance characteristic.

to minimize the junction capacity and negative resistance of the intrinsic device as well as the parasitic resistance and inductance associated with the connecting leads.

Germanium tunnel diodes (type *ZJ56*) currently in production at the General Electric Company and packaged in miniature header assemblies have the following approximate equivalent-circuit parameter values: $R_i = 100$ ohms, $C_i = 10$ μμf (micromicrofarad), $L_s = 10$ mμh (millimicrohenry) and $_{Rs} = 1$ ohm. Thus, it is apparent that both ω_R and ω_s are of the order of 10^9 radians per second. Considerably higher values of ω_R and ω_s may be obtained by packaging the tunnel diode in a strip line configuration; for example, oscillation frequencies of 10 kmc (kilomegacycle) have been reported with strip-line tunnel diode assemblies[14].

CIRCUIT APPLICATIONS

SINCE THE TUNNEL DIODE is an active device, it may be used in communication-type applications as a gain element in oscillator, converter, or amplifier circuits.

For example, Fig 10a illustrates a relaxation oscillator configuration where the period of oscillation is determined principally by the discharging time constant of the externally connected inductance, L. Resistors R_1 and R_2 are used to establish the proper d-c operating point in order to insure an astable circuit condition; i.e., the d-c load line must intersect the negative resistance characteristic of the tunnel diode in the negative resistance region only. The period of oscillation for low frequencies ($\omega \ll \omega_x$) is then given approximately by

$$t_p = \frac{L}{R_1} \ln \left[\frac{(E/R_2) - I_v}{(E/R_2) - I_p} \right] \qquad (3)$$

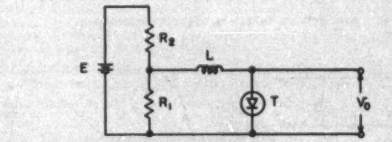
where I_v and I_p are the valley and peak current values, respectively, of the tunnel diode characteristic and where it is assumed that R_2 is much larger than R_1. The oscillation may be made essentially sinusoidal by resonating the external inductance with a parallel capacitor or by reducing the inductance to a value where it effectively resonates with the internal capacity of the diode (the oscillation frequency then becomes comparable, within an order of magnitude, to ω_s).

A tunnel diode tuned amplifier circuit configuration is illustrated in Figure 10b. The inductance L is tuned to the internal capacity C_i of the tunnel diode so that resonance is obtained at the desired center frequency of the channel. The available gain of the circuit G_{av}, which is defined as the power delivered to the load conductance ($G_L = 1/R_L$) divided by the power available from the generator, is given at the resonant frequency by

$$G_{av} = \frac{4\, G_G\, G_L}{(G_G + G_L - G_i)^2} \qquad (4)$$

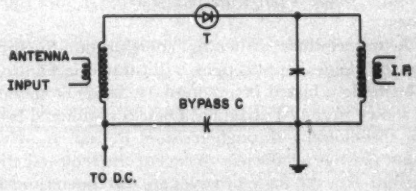
where G_G is the source conductance and G_i is the magnitude of the negative conductance of the tunnel diode. Thus, amplification is obtained by reducing the positive conductance of the passive circuit components with the negative conductance of the tunnel diode. In order to prevent oscillation, the net conductance of the complete circuit must be positive.

Fig. 10c illustrates a tunnel diode converter circuit



a) RELAXATION OSCILLATOR

b.) TUNED AMPLIFIER (a.c. CIRCUIT)



c.) CONVERTER STAGE

Fig. 10. Tunnel diode circuits.

which performs simultaneously the functions of oscillation, mixing, and amplification.

The converter circuit exhibits two parallel resonances and the circuit is loaded so that oscillation is obtained only at the resonance corresponding to the desired local oscillator frequency. Mixing is obtained as a result of the strong nonlinearity of the tunnel diode negative resistance characteristic. Since the tunnel diode is biased in the negative-resistance region of operation, amplification can be obtained at both the r-f and i-f frequencies. Oscillation at these frequencies is prevented by proper loading of the tuned circuit.

A second major area of potential application of the tunnel diode is in digital data-processing systems. Like all negative-resistance devices, the tunnel diode may be operated in a monostable mode to supply regenerative

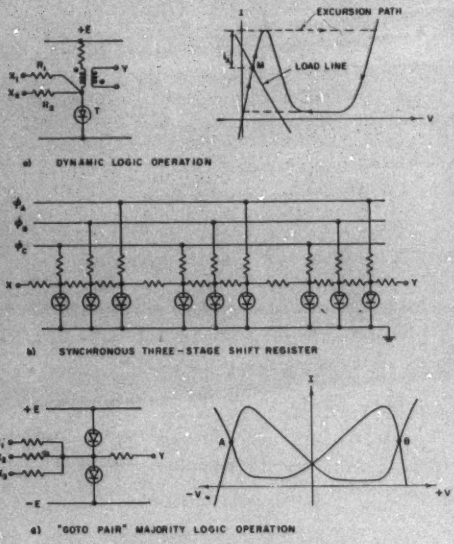


Fig. 11. Tunnel diode switching circuits.

gain to trigger pulses or in a bistable mode to act as a switch. The high-speed potential and low-power dissipation of the tunnel diode, together with its other attributes, make it particularly attractive in such applications.

A tunnel-diode switching configuration useful for dynamic logical applications is illustrated in Figure 11a. The diode is biased in a monostable mode of operation, as shown in the *I-V* diagram. Logic is performed by analog thresholding through resistors R_1 and R_2. If each input current is sufficient to exceed the required trigger current (i_s), the logic provides an "or" operation; however, if both input currents are required to trigger the stage, the logic provides an "and" operation. Inversion may be obtained by polarity reversal through a transformer followed by additional logic. Since the tunnel-diode stage is bilateral, unlilateralization must be provided by circuit techniques, such as the use of an intermediate delay stage between input and output. In other respects, the interconnection of dynamic tunnel-diode logic stages is similar to that used in conventional dynamic pulse systems[15].

If the tunnel diode is biased in a bistable mode, such that a stable operating point exists in both the low- and high-voltage regions of the *I-V* characteristic, the function of "memory" is obtained. However, it is difficult to use a single bistable tunnel diode as a flip-flop because of the lack of trigger symmetry in switching between stable points; i.e., trigger gain may be achieved reliably in only one direction. If a reset clocking signal is provided, the difficulty is overcome. Figure 11b illustrates a tunnel diode shift register in which each diode is operated in a bistable mode and in which a 3-phase supply voltage is used to effect information flow from left to right. Each diode is reset during the negative half-cycle of the supply. The logic interconnection scheme employed is similar to that used in parametric subharmonic oscillator systems.[16]

Fig. 11c illustrates a majority logic stage proposed by Goto consisting of two series-connected tunnel diodes connected to a symmetrical positive and negative voltage source. Positive or negative outputs are obtained depending upon which of the diodes has been switched to a high-voltage state. Since each input to a logic stage consists of a positive or negative signal, an odd number of inputs must be used to obtain a definite net-positive or negative-trigger signal. If the net input signal is positive, the lower diode will be switched into a high-voltage stage; the sum of the two complementary supply voltages is not sufficient to allow both tunnel diodes to be switched into high-voltage conditions and hence the upper diode will be maintained in a low-voltage state. Thus, the output signal will very nearly be equal to the positive supply voltage (operating point *B* in Fig. 11c). As with the single tunnel diode stage, the "Goto pair" is bilaterial and consequently a 3-phase clocking scheme similar to the one illustrated in Fig. 11b must be used to provide the proper direction for information flow. Although the Goto scheme requires the use of closely matched diodes in each pair, it does provide a method for operating majority-logic resistor nets with positive and negative input signals and, thus, allows greater passive component tolerances than would be acceptable with a single tunnel diode as well as a convenient means for using a simple transformer as an inverting element.

The backward diode may be used in combination with tunnel diode logic circuits to provide nonlinear signal paths between stages.[17] In this application the backward diode performs a function analogous to ordinary logic diodes; however, the backward diode is better suited to be used with tunnel diodes because of the very small conducting voltage drop relative to ordinary diodes when biased in the "backward" direction. Use of backward diodes in combination with the logic resistors

in the circuits shown in Fig. 11 would increase the allowable tolerances of the passive components or would increase the fan-in and fan-out factors permitted for a given set of component tolerances.

CONCLUSIONS

The tunnel diode offers many physical and electrical advantages over conventional semiconductor devices; these include: potentially low cost, environmental ruggedness, reliability, low power dissipation, high-frequency capability and low-noise properties. Thus, the tunnel diode is assured a useful and significant place in electronic circuit applications.

In communications, the tunnel diode can provide amplification, oscillation, mixing, and detection. The fact that tunnel diodes can be used in the uhf and microwave-frequency regions makes the device competitive with parametric amplifiers. Although the noise figure for the tunnel diode is somewhat less favorable than for the most optimized parametric converter, the tunnel diode is considerably simpler to use. Thus, it may be concluded that in uhf and microwave-receiver front-end applications where the ultimate in low-noise performance is not required, the tunnel diode will find considerable use; competitive transistors are not yet in sight. In lower frequency applications, such as commercial radio, the tunnel diode faces a much more formidable competitor in the transistor. The problems associated with the use of bilateral negative-resistance devices to provide stable gain in multistage amplifier networks are not insignificant. Hence, although the tunnel diode may find use in specialized circuits such as oscillators and low-level detectors, transistors may be expected to continue to provide the basic amplification functions at frequencies below uhf in ordinary commercial and military communications equipment for some time to come.

In digital data-processing applications, the tunnel diode must be evaluated against transistors, cores, and parametric devices. Many of the problems which arise in using tunnel diodes in pulse circuits stem from two properties of the device: its 2-terminal nature and the low-voltage excursion between its "on" and "off" states. For example, the 2-terminal structure of the device requires the use of multiphase circuit techniques to provide input-output isolation; thus, some speed capability is lost, particularly in sequential logic operations. Since the voltage excursion is low, ordinary diode gates cannot be used for logic and, hence, analog summing circuits must be employed; this leads to narrower component tolerances than are generally used in the design of transistor switching circuits.

In assessing the future role of tunnel diodes in digital systems, operating under normal environmental conditions, it seems fairly certain that tunnel diodes will play a major role in systems operating at vhf bit rates. Transistor circuits are expensive and inefficient as bit rates increase beyond 10 mc. When bit rates exceed 100 mc, the stringent tolerance requirements of tunnel diode circuits may become intolerable due to reactive effects and hence parametrically operated devices may have the practical edge. Consequently, the tunnel diode may be expected to fill the important frequency gap between 10 mc and 100 mc in general computer applications. Equally as promising is the application of tunnel diodes in high-speed memories; read and write cycles of 10 mc have already been reported for experimental memories using the Goto pair (Fig. 11c) as the basic storage cell in moderate-size memory banks.[18]

Also to be considered are the many applications which the unique characteristics of a new device make possible, but which cannot be ascertained accurately until long after the device has been introduced. For example, the tunnel diode may find use in such applications as a switch for transistors, cryotrons, and controlled rectifiers. In addition, the use of tunnel junctions in combination with normal p-n junctions may make possible complex devices with novel characteristics. Finally, the use of the tunnel diode in microminiaturized electronic equipment may become increasingly important because of its inherent stability and low-power dissipation.

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James F. Fairman

1959 Edison Medalist

" . . . for outstanding performance in improving the design of large electric power systems; for far-sighted leadership in atomic power development; and for unremitting efforts to improve the engineering profession."

History of the Medal

A. C. MONTEITH
FELLOW AIEE

THE SELECTION of an Edison Medalist forces a group of people to stop and assess the accomplishments of those who have contributed to the progress of the electrical industry. This is good, because, with the tempo at which everyone moves today, we are inclined to take much for granted. Only by periodical assessments do we appreciate the accomplishments of many, and perform the difficult task of selecting one.

The Edison Medal was founded by an organization of associates and friends of Thomas A. Edison, to serve ". . . as an honorable incentive to scientists, engineers, and artisans to maintain by their works a high standard of accomplishment." The Medal is awarded annually by the Edison Medal Committee of the AIEE to some one resident of the United States of America and its Dependencies or of the Dominion of Canada for ". . . meritorious achievement in Electrical Science, or Electrical Engineering, or the Electrical Arts." This Medal is considered by all as the highest award of the Institute, which is emphasized by the character of the recipients.

Mr. President, the Edison Medal Committee members feel that even greater stature is given to the distinguished list of scientists, engineers, and artisans who have received the Edison Medal by the addition of the name of James F. Fairman as 1959 Medalist.

Presentation and acceptance addresses made at the Edison Medal ceremonies during the AIEE Winter General Meeting, New York, N. Y., Jan. 31-Feb. 5, 1960.

A. C. Monteith, chairman of the Edison Medal Committee, and past president of the AIEE, 1954, is vice-president, engineering, Westinghouse Electric Corporation, Pittsburgh, Pa.

H. C. Forbes is chairman of the board, Consolidated Edison Company of New York, Inc., New York, N. Y.

Career of the Medalist

H. C. FORBES
FELLOW AIEE

ON AN OCCASION such as this it is customary to review the career of the man we honor. In so doing, I expect many of us will reflect once again on our own lives and refresh our sense of dedication to and belief in the worthiness of our work. From the career of James F. Fairman comes a renewed faith in our educational system, our profession, and the ability of every individual to shape his destiny rather than be captive to it.

Born in Big Rapids, Mich., in 1896, our Edison Medalist was a loyal Wolverine and attended the University of Michigan at Ann Arbor. He received the bachelor of science degree in electrical engineering in 1918, and 3 years later was granted the master of science degree. After taking the graduate student course of the Westinghouse Electric Company in East Pittsburgh, Pa., he heeded a call to return to the University of Michigan in 1919 where he served as instructor in electrical engineering until 1922, when he was appointed assistant professor.

In 1925, Jim decided that it would be an agreeable change to do some engineering himself instead of teaching others how to do it, and he even went so far as to desert his beloved Midwest for the East Coast, where he joined the Brooklyn Edison Company as assistant outside plant engineer. There ensued a meteoric advancement. The following year he became outside plant engineer, and before the year's end he had been named assistant electrical engineer. In 1932, he received the title of electrical engineer. In 1937, following the merger of Brooklyn Edison, together with several other companies, into Consolidated Edison, Jim continued as electrical engineer of the Consolidated Edison organi-

zation. In 1941, he was elected an officer of Consolidated Edison—assistant vice-president with the assignment of sharing in the direction of design, inventory, purchasing, and stores. In 1945, he was elected vice-president of Consolidated Edison and he then assumed the direction of electric and gas production and operation.

In April 1951, Consolidated Edison temporarily surrendered its claim to Jim's services when he was appointed deputy administrator of the Defense Electric Power Administration by the United States Secretary of the Interior. In July of that year he was named administrator, in which position he continued until November 1952.

Following his service at Washington, Jim returned to Consolidated Edison as vice-president in charge of engineering. In 1957, he was elected to the newly created office of senior vice-president, in which capacity he continues to give that company the benefit of his broad experience as an engineer and a competent director of varied assignments which usually have one thing in common—they are so difficult that most people would prefer not to tackle them.

Throughout his career, Jim has taken a keen interest in and has contributed much to the American Institute of Electrical Engineers. He was chairman of the New York Section, 1940-41; vice-president of the Institute, 1944-46; director, 1946-49; and president, 1949-50 For good measure, he has rendered distinguished service on many of the Institute's committees.

He also has been active as a member of the National Society of Professional Engineers, having served as president of the New York State Society during the years 1942-44, and vice-president of the Northeastern area during the years 1946 and 1947. Since 1953, he has been a member of the New York State Board of Examiners for Professional Engineers and Land Surveyors.

In recent years, Jim has been very active in the national program for development of nuclear power, and has had general direction of the engineering of Consolidated Edison's Indian Point nuclear electric generating station. He is a director and vice-president of Atomic Power Development Associates, a nonprofit organization presently doing research and design work in the field of fast breeder reactors. He is chairman of the Technical Appraisal Task Force on Nuclear Power of the Edison Electric Institute, and chairman of the Committee on Nuclear Energy of the National Association of Manufacturers. Since 1956, he has been a member of the New York State Atomic Energy Advisory Committee appointed by the Governor.

How Jim ever found the time, in the midst of this remarkable record of activities, to write the numerous papers on professional subjects that have appeared under his authorship in *Electrical Engineering* and various trade publications is a mystery that deserves careful investigation. Finding an answer to it should result in an addition to our national resources of human energy that would put to shame the modest increment that has been made to our fuel resources by the discovery of nuclear fission.

Having sketched for you what I can only characterize as the skeleton of Jim's career, it would be indecent to leave it without dressing up the bare bones with some of the things that give substance to the make-up of an extraordinary man.

The business, with which Jim has so long been concerned, of producing and distributing energy to the public is one to challenge the highest talents of the engineering profession. The customers of the utility companies demand more and more for less and less, and those who furnish the companies with the necessities of their business usually like to furnish less and less for more and more. In this kind of an atmosphere there was room for the full play of Jim's talents. Somehow he always seemed to know how the many things that go into the make-up of a public utility system could be put together in such a way as to keep down the cost, improve the efficiency, and operate with a smaller number of people. Anyone who stood in the way of his efforts to achieve these worthy objectives was likely to find that Jim's natural leaning toward persuasiveness could, on occasion, be supplanted by explosiveness.

Nor was he disposed to look with equanimity upon the proclivity that I have mentioned of the suppliers to furnish less for more. To combat this tendency, his talents came into play in studies which led to the factory standardization of underground transformers, switchgear, and electric connections. Success in working out a program of standardization is a rare tribute, for I suppose there is nothing else in the world that is so enthusiastically supported in principle and so skillfully sabotaged in practice as standardization.

It is likely, however, that the true breadth of Jim's abilities might never have been fully appreciated had it not been for his service as administrator of the Defense Electric Power Administration during the Korean War. This task undoubtedly was one of the most delicate ever to be undertaken by a public utility executive. I am sure that many times Jim must have felt like the headmaster of a private school who finds himself confronted with the unpleasant necessity of notifying one of the school's principal financial supporters that his son is about to be suspended for ungentlemanly conduct. Suffice it to say that Jim conducted the affairs of the Defense Electric Power Administration with such competency and such even-handed fairness that he commanded the respect of governmental agencies as well as the public utility industry.

On the occasion of his retirement, he received from the Secretary of the Interior a citation for his ". . . outstanding leadership and exemplary service in the furtherance of the national security and defense." The delicacy of Jim's assignment was noted in the citation by the comment that "In an industry fraught with a divergence of opinion on the matter of ownership of power supply facilities, Mr. Fairman, through his inspiring leadership and fairness, obtained unparalleled unity of effort and purpose."

Presently, in his activities in the field of nuclear power, Jim once more finds scope for the broad range

of his remarkable talents. Here is a development that requires technical competence of the highest order, a sensitivity to the shifting winds of political controversy, and an ability to reconcile the disparate elements of science, engineering, manufacture, and operation.

Here, perhaps, as never before, Jim is called upon to exercise those qualities of greatness that have prompted us to honor him today. We honor him as much for his willingness to undertake the numerous assignments that he has so ably discharged as for his ability to do them well.

Acceptance of the Medal

J. F. FAIRMAN
HONORARY MEMBER AIEE

HAVING BEEN A PARTICIPANT in this ceremony on a number of occasions, as chairman of the Edison Medal Committee and as president of the Institute, I am deeply sensible of the honor explicit in the role I play today. The members of the Institute have been most generous to me and I am deeply grateful.

Precedent suggests that the Medalist's response may well have some relationship to the citation accompanying the medal. In this instance, the citation mentions "leadership in atomic development" and "efforts to improve the engineering profession." These clues set me to thinking about an age-old problem which presents a special challenge to engineers in this atomic age.

The taming of the atom opens the door to a multitude of uses for the benefit of mankind. Every conceivable application of atomic energy to peaceful uses affords opportunities to engineers not only to apply their special skills but also to promote public understanding and acceptance of their work.

The pundits are filling our ears and minds with warnings of population explosions and the restless stirrings of people less fortunate than we of the West. The masses of Asia and Africa are becoming aware of the vast differences between their way of life and ours. Their leaders are accelerating a drive for industrialization which is the hallmark of our civilization.

Here at home, the mechanization of our productive effort continues at a massive rate. Automation is the order of the day. Punched cards or magnetic tapes control the operation of complex machines in mills and factories. Bookkeeping is done on electronic computers. The modern housewife can now wash and dry the family clothes and do the dinner dishes while she watches television.

We cannot halt this tide of industrialization and mechanization even if we should want to. Nor can we turn our backs on it as if it did not exist. The tide will roll on, and as it gathers strength, it will make ever growing demands on the energy resources of the world.

Faced with this prospect, one of the great responsibilities of the engineering profession is to advance the art of atomic power production so that this new source of energy may be brought to commercial development in time to supplement and ultimately to take the place of the earth's diminishing store of nonrenewable energy resources. If our world is to have the energy it will need when it needs it, all sources of energy must be exploited to their fullest extent.

Engineers have a second major responsibility, to devise ways and means of tapping atomic energy and other energy sources economically and safely.

I believe these two responsibilities are generally accepted and ultimately will be achieved. I want to discuss more fully a third responsibility because it is one to which our profession has given least attention, and which I believe to be of equal importance.

We have a responsibility to obtain public understanding of the engineering problems involved in our work and public acceptance of the results we achieve. The need to fulfill this responsibility has become increasingly evident during the past few years as atomic energy has moved into the public domain.

The present drive to achieve nuclear power has been hampered as much by the general public's lack of understanding of the economics of power production and its uneasiness concerning safety as by any other factors.

When I encounter these manifestations and recall the still unsolved technical problems, I am deeply concerned by what is disseminated by our mass media. Those who play upon the fears of people contribute nothing to the solution of the problem and ignore the inevitable need of all mankind for new energy resources. Those who envision "pie in the sky" while dismissing the cost and ignoring the blank spaces in our knowledge contribute to a debilitating disillusionment.

There is nothing new about this. I imagine the original "P.E." (Pithecanthropus Engineericus, that is) may have felt similar frustrations when he discovered how to start a fire by striking two stones together. Some cavemen may have derided his achievement because a man could always find a fire from which to snatch a burning branch. Perhaps some of his neighbors demanded he throw away his stones because they would be hazardous in the hands of children. Some wives may have ordered their husbands never to have a fire inside the cave because of the smoke.

Perhaps P.E. was also irked by those who began to make extravagant promises about the future. Did one of our forebears snatch up a piece of charcoal and sketch on the nearest cliff a rough picture of the contemporary equivalent of the good life? Did visionaries predict that soon P.E. would find a way to burn black rock, or the greasy stuff found floating on the water in a nearby bog?

While some may have been filled with dread and others dreamed, I imagine that P.E. in his own stumbling way learned he could control his fire. He

J. F. Fairman, past president of the AIEE, 1949, is senior vice-president, Consolidated Edison Company of New York, Inc., New York, N. Y.

found he could protect his family from wolves by a fire at the mouth of his cave. He discovered that smoke from a fire in the cave would pass through a hole in the roof above the fireplace. He experimented to find which wood was best for cooking his dinosaur steak and which burned longer as a protective fire.

Am I being too fanciful? Perhaps. Yet all of us, I am sure, can recall modern parallels. Let me hasten to add that concern about the safety of what we are doing, and dreams of a better world as a reward for what we accomplish have their proper place. My objections are aimed at misrepresentations of engineering accomplishments which create false impressions in the minds of the uninitiated.

Unfortunately, the atom made its debut in society as an engine of destruction. Subsequent testing of atomic weapons and emotional discussions of fall-out have added to public concern. The "iron curtain" of secrecy which surrounded the atom for so many years did nothing to dispel the public's misgivings. The outstanding personnel safety record achieved in this new industry has not been headline material.

As a result, Government agencies officially concerned with public health and safety are amending their codes to include radiation hazards, and since experience and data are lacking on which to base standards, there is an understandable tendency to excessive conservatism. Heretofore, health and safety rules and regulations generally have been based on proven experience. To base them on exaggerated hypothetical incidents can place a severe handicap on progress.

On the other hand, there has been some fantastic optimism, notably in the matter of future costs of atomic power, expressed by persons whose word carries great weight. The statement made several years ago that "It is not too much to expect that our children will enjoy in their homes electrical power too cheap to meter," is still being quoted, sometimes even by persons who, on reflection, would have grave doubts about it. May I point out that here in New York, even if the atom cost us nothing as fuel, and if the elaborate apparatus for splitting it, capturing its heat, and transforming the heat into electricity were free, your electricity would still cost you about two thirds of what it does today—unless you could come to our power houses and carry it home with you on a "cash and carry" basis.

While we pursue our professional goals of safety and economy, we also have a responsibility to educate the public. The other day I dusted off a copy of the Statement of Principles of Professional Conduct of this Institute. I had a little trouble finding it. It used to be contained in the year book. On inquiry I learned it had been removed because it was so infrequently referred to. I was reminded of the family Bible which once occupied a prominent place on the sitting room table, then was removed to a book shelf where it collects dust, if indeed, it has not disappeared entirely from the "family room." The following two sections of this statement are taken from the portion headed "Relations with the Public."

Ross Photos

Edison Medalist J. F. Fairman (second from right) is congratulated by H. C. Forbes (left), who described his career; A. C. Monteith (second from left), who gave the history of the Medal; and Prof. R. T. Weil, general chairman of the Winter Meeting.

Sec. 3. The engineer will endeavor to extend public knowledge of engineering, and will discourage the spreading of untrue, unfair, and exaggerated statements regarding engineering.

Sec. 7. He will refrain from expressing publicly an opinion on an engineering subject unless he is informed as to the facts relating thereto.

In this day and age, when most of us do our work for and through some form of corporate organization, the individual engineer may not feel direct responsibility for what is said by others in the name of his organization. But can we completely absolve ourselves of any responsibility? If engineering is, in fact, a profession, those who practice it, individually or as members of a group, must apply their principles and make clear to others responsible for public statements on engineering subjects the necessity for truth and accuracy.

As part of its over-all attack upon the problems besetting the world today our nation has launched the program called Atoms for Peace. Atomic energy for the production of electricity is an integral feature of this program. As its contribution to Atoms for Peace, our profession can overcome the technical obstacles to economic atomic power production and we can contribute to public understanding and acceptance of our work. Above all, we must exercise care that engineering does not become another tool of the propagandist, the fear-monger, the huckster.

If we are to assist in increasing public understanding and acceptance of our efforts to develop this new energy source, we must clearly separate the things that we know and can prove from the things we hope for. We must think before we speak and we must speak in terms people can understand. We must be bold to question extravagant claims and wishful thinking as well as unwarranted fears held by well intentioned but inadequately informed individuals or groups.

The public has much to gain from the success of our

endeavors. The advantages of a power plant that can safely be placed close to the load it serves without contributing a whit to air pollution will become increasingly important as the urbanization of the United States continues. The addition of a competitively priced source of energy to meet the nation's needs serves both national policy and the public's requirements.

The public's interest has been aroused. People want to know, to read, and to see what we are doing. They come to us in a receptive frame of mind. They ask good questions. They like straightforward answers. If correctly and adequately informed, they can be most helpful in creating an atmosphere favorable to progress. We have a wonderful opportunity to tell our story. We have a grave responsibility to adhere to facts and to avoid fantastic prophecies. We can meet this challenge if we will.

To the extent that we do meet it, we shall enhance the status of engineers and of the engineering profession.

Design of an Eddy-Current Brake for a Sodium-Cooled Reactor

R. S. BAKER
MEMBER AIEE

Eddy-current brakes have proved very effective for throttling sodium flow in a sodium-cooled nuclear power reactor, thus maintaining a constant temperature gradient for afterglow conditions. Design steps and calculations are presented.

THE SODIUM-COOLED nuclear power reactor, known as the Sodium Reactor Experiment (SRE), is operated by Atomics International, a division of North American Aviation, Inc., for the U. S. Atomic Energy Commission. The reactor is located in the Santa Susana Mountains near Los Angeles, Calif. The design features of this reactor have been outlined by Dr. S. Siegel.[1]

During the early operation of this reactor, it was determined that some form of sodium-flow throttling device was necessary to prevent excessive thermal stresses from occurring in the reactor core and sodium piping after a shutdown, or "scram."

When the reactor is shut down, the production of heat within the reactor becomes a small fraction of its former value. This small amount of heat (due to afterglow) that is still being produced is sufficient to cause circulation of sodium into and out of the reactor by thermal convection. The result is that sodium, at a relatively low temperature, is brought into contact with piping which is still at a high temperature, thereby leading to excessive thermal stresses. These stresses can be minimized by controlling the sodium flow in proportion to the heat generation, resulting in constant temperature gradients.

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METHOD USED TO CONTROL FLOW AFTER SHUTDOWN

FOR THE PURPOSE of throttling the sodium flow throughout the reactor piping to maintain a constant reactor temperature gradient for afterglow power conditions, two eddy-current brakes were installed in the SRE. One is used on the primary piping system; the other on the secondary system. Each is constructed as shown in Fig. 1. Both brakes are controlled by thermocouples that measure sodium temperatures in primary and secondary systems.

Performance has been satisfactory. The braking pressures that have been obtained at different sodium flow rates agree with calculated figures.

DESIGN CALCULATIONS

Determination of Required Flux Density. To begin the design of the d-c electromagnet which constitutes the brake, a basic configuration was assumed. This is shown in Fig. 1.

Dimensions of the braking section and thermal barriers are shown in Fig. 2. The symbols that appear in Fig. 2 represent quantities that will be used later in the design calculations. Fig. 3 shows dimensions of the braking section and pole face in planes parallel to the flow direction. Fig. 4 is a side view of Fig. 1. The yoke is shown in Fig. 5.

The calculation of magnet design to produce a given braking pressure is based on Rudenberg's equation for the eddy-current drag on a copper disk.[2,3] Written in

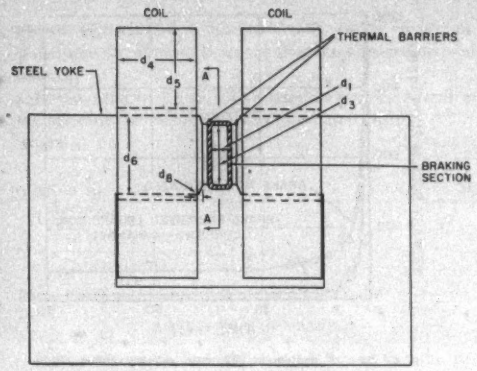

Fig. 1. Eddy-current brake, showing cross section of braking section.

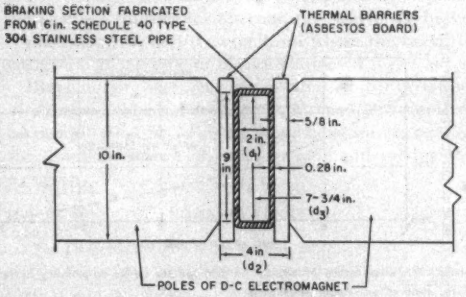

Fig. 2. Cross section of braking section.

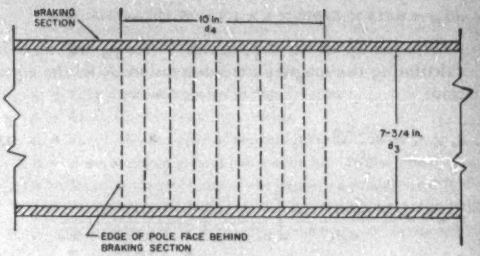

Fig. 3. Section A/A of Fig. 1.

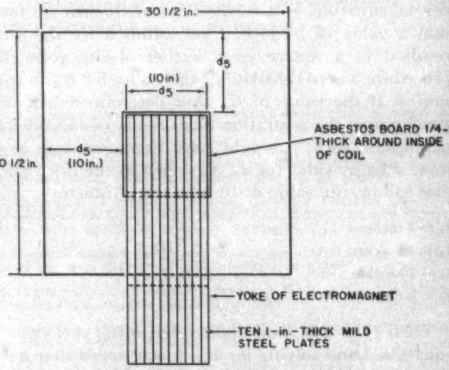

Fig. 4. Side view of eddy-current brake.

terms of the quantities used in designing the eddy-current brakes, this equation becomes:

$$P = \frac{8.5 \times 10^{-16} QB^2 G}{r_1 d_1} \left[\frac{\frac{d_2}{d_4} + \frac{d_4}{d_2}}{\left(\frac{39.2 \times 10^{-9} Q}{r_1 d_1}\right)^2 + \left(\frac{d_2}{d_4} + \frac{d_4}{d_2}\right)^2} \right] \quad (1)$$

In test runs conducted at the SRE, it was determined that under scram conditions, the sodium flow rate in the main primary circuit, through the reactor, should drop to about 12 gallons per minute. It was also determined that the eddy-current brake should cause a dragging pressure of 0.3 pound per square inch at this flow rate. The flux density necessary to produce this drag pressure was calculated from equation 1 for a sodium temperature of 1,000 F.

P = 0.3 pound per square inch
d_1 = 2 inches
d_2 = 4 inches
d_3 = 7¾ inches
d_4 = 10 inches (this value was determined by adding an estimated amount of 2.25 inches for pole face chamfer to d_3)
Q = 12 gallons per minute
r_1 = 10.5 × 10^{-6} ohm-inches

Solving for B_G:

B_G = 35,800 lines per square inch

Calculation of Magnetomotive Force Required. The next step in the design was the calculation of the coil ampere-turns required to set up this flux density. Two coils were used, one on each side of the air gap, and placed as close as possible to the gap. Each coil was proportioned to have the maximum ratio of inductance to resistance, as nearly as possible. This requires that each coil be square in cross section, with a mean diameter which is 3.02 times the length of one side.[4,5] (See Figs. 1 and 4.) It was not possible to construct the magnet yoke to meet this requirement precisely, because of space limitations; however, the actual performance has not been measurably affected.

The effects of fringing and leakage were taken into account by empirical and analytical methods.[6,7] The first of these, the fringing effect, causes an increase in the magnetomotive force as denoted by the fringing factor f_1 in the equation

$$AT_G = 0.313\, B_G d_1 f_1 \quad (2)$$

From page 14 of reference 6, $f_1 = 1.5$. Thus,

$AT_G = 0.313 \times 35{,}800 \times 4 \times 1.5 = 67{,}100$ ampere-turns

The second effect, the leakage factor f_2, was used in calculating the magnet yoke dimension d_6 in the equation:

$$d_4 \times d_5 = \frac{f_2 B_G A_G}{B_m} \tag{3}$$

$$f_2 = 1 + \frac{3.4\, d_1(d_4 + d_5)}{d_4 d_5}\left[\frac{d_5}{d_2 + d_5} + \frac{0.45\, d_4}{d_2 + 0.67\, d_4 + 2d_3}\left(1 + \frac{d_2 + 2\, d_3}{d_4}\right)\right] \tag{4}$$

The values of the quantities in the right-hand member of equation 4[7] are listed below. It will be noted that a value of 10 inches was assumed for d_6, which resulted in a square cross section of the yoke. The procedure was to calculate f_2, then solve for B_m in equation 3. If the value of B_m thus determined had been greater than the saturation flux density of 115,000 lines per square inch, it would have been necessary to assume a larger value for d_6. As shown by the calculations that follow, the value of 10 inches is satisfactory.

$d_2 = 4$ inches
$d_4 = 10$ inches
$d_5 = 10$ inches
$d_3 = 0.5$ inch

Then $f_2 = 2.86$, and upon substituting this value in equation 3 and solving for B_m, it was found that $B_m =$ 102,000 lines per square inch, which is a satisfactory operating flux density for the steel yoke. The reluctance drop in the steel from one side of the air gap, through the yoke around to the other side, was found to be 8,880 ampere-turns.[8] This amount was added to the air gap ampere-turns calculated in equation 2 to determine the wire size necessary for the coils.

Coil Design. The next step in designing the brake was to assume a coil current I of 10 amperes d-c. Then, under the assumption that the coil is square in cross section, $d_4 = d_5 = 10$ inches.

The mean length of turn d_7 was calculated as follows:

$$d_7 = 2(d_4 + d_5) + 2(d_5 + d_5) = 2(d_4 + 2d_5 + d_5) = 80 \text{ inches}$$

The cross-sectional area of the coil conductor for a winding temperature of 60 C (140 F) was calculated from the equation:[9]

$$A = \frac{k d_7 NI}{1.16E} \tag{5}$$

where

$$k = \frac{100}{98} + 0.004(60 - 20)$$

$= 1.18$ for copper of 98% conductivity at 60 C

$$NI = \frac{67{,}100 + 8{,}880}{2} = 37{,}990 \text{ ampere-turns per coil}$$

$E = 120$ volts

$$A = \frac{1.18 \times 80 \times 37{,}990}{1.16 \times 120} = 25{,}200 \text{ circular mils}$$

No. 6 Awg (American wire gauge) double-glass insulated wire was used for winding the coils, each of which was wound with approximately 3,400 turns. The cross

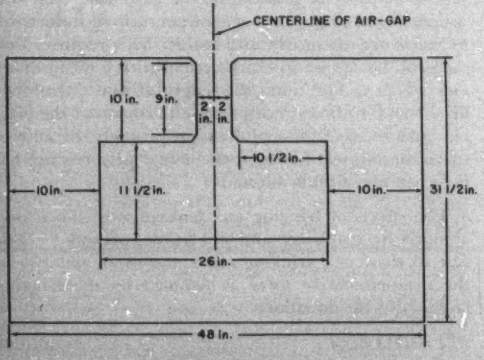

Fig. 5. View of yoke without coils and braking section.

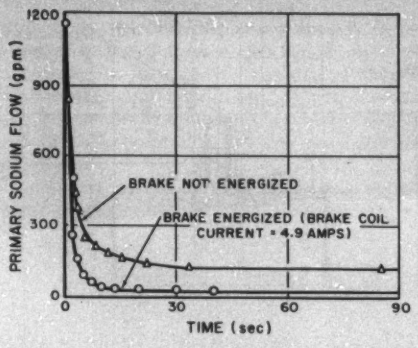

Fig. 6. Flow of sodium in SRE main primary piping circuit reactor to heat exchanger vs. time after reactor shutdown.

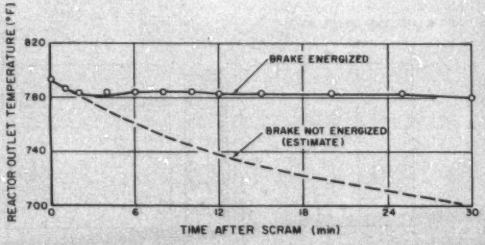

Fig. 7. Temperature of sodium at SRE reactor outlet to primary system vs. time after reactor shutdown.

section of each coil is approximately 10 by 10 inches; therefore, the initial choice of magnet dimensions was correct.

Power Loss in Coils. The resistance of each coil at the operating temperature was calculated from[9] where

$$r_2 = \frac{kd_7N}{1.16A} \tag{6}$$

$$r_2 = \frac{1.18 \times 80 \times 3{,}400}{1.16 \times 22{,}700} = 12.2 \text{ ohms}$$

Power loss in each coil = 10 × 120 = 1,200 watts

BRAKE PERFORMANCE

THE EFFECTS of the eddy-current brake on the primary system are shown in Figs. 6 and 7. These curves illustrate the manner in which sodium flow in the primary system and sodium temperature at the reactor outlet vary with time for the condition where the brake is not energized, and the condition where the brake is energized, at the time of reactor shutdown.

Dragging pressure may be maximized by variation of d_3 or d_4. The value of d_3 or d_4 may be found by taking $\partial P/\partial(d_3)$ or $\partial P/\partial(d_4)$ from equation 1, setting the resultant expression equal to zero, and solving for d_3 or d_4.

NOMENCLATURE

P = Dragging pressure in the sodium, psi

Q = Sodium flow through the braking section, gallons per minute

d_1, d_2, d_3, d_4 = Dimensions of braking section, shown in Figs. 1, 2, and 3, inches

B_G = Flux density in sodium, lines per square inch

r_1 = Resistivity of sodium, ohm-inches

f_1 = Fringing factor, dimensionless

f_2 = Leakage factor, dimensionless

AT_G = Ampere-turns for the air gap

B_m = Flux density in steel yoke, lines per square inch

d_5 = Coil dimensions shown in Fig. 1, inches

d_6 = Yoke dimension shown in Fig. 1, inches

d_7 = Mean length of coil turn, inches

d_8 = Space between edge of coil and pole face, inches

A = Cross-sectional area of coil conductor, circular mils

k = Ratio of the resistivity of the copper conductor used in the coil winding to that of standard annealed copper at 20 C. For copper of C per cent conductivity at T degrees C,

$$k = \frac{100}{C} + 0.004(T - 20)$$

N = Number of turns per coil

I = Coil current, amperes

E = Coil voltage

r_2 = Resistance of each coil at the operating temperature, ohms

A_G = Area of pole face, square inches = d_4d_8

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Turntable for Lamination Stacking

Stacking of stator punchings for large diameter motors and generators has been expedited at the Allis-Chalmers Manufacturing Company's West Allis Works by means of a motorized rotary table. The turntable, which can be adjusted to accommodate different diameter stators, has platforms for stackers and laminations at each end. Stackers ride on the rotary table around the inside of the stator, placing laminations over the stator dovetails.

The device has proven a big time and energy saver, since formerly stackers walked back and forth inside the stator area. Here the turntable is being used to stack laminations in a stator for the New York State Power Authority's Tuscarora pump–turbine project on the Niagara River. One of 12 similar units, the stator is about 20 feet in diameter and requires some 45,000 laminations.

Mixed Transcendental and Polynomial Transforms

O. J. M. SMITH
MEMBER AIEE

A MIXED TRANSCENDENTAL and polynomial transform is obtained by cascading a transmission line and a time constant. The substitution of the variable y for $\exp(-sT)$ facilitates a variety of manipulations of these transforms. The impulse response of a system of transmission lines connected in cascade and in parallel can be only a finite number of impulses. This has zeros only in the finite y plane. If the transmission line is connected in feedback, then a train of impulses extending to infinite time can be generated. This must be represented by poles in the y plane. Each y-plane pole is an infinite column of s-plane poles.

A ratio of polynomials in y represented by $G(y)$ can be evaluated geometrically in the y plane. It is a constant times the distance product equal to the product of the distances from all of the zeros to the point y divided by the product of the distances from all of the poles to the point y. A spirule or a complex-function computer can be used to read the distance product.

Posicast control systems have a delay-line compensator prior to a lumped-parameter system. For a single impulse input, the compensator delivers a chain of impulses of finite number and these excite the lumped-parameter system in such a manner that it reaches its final value in finite time and the output of the lumped-parameter system remains constant at its final value thereafter. This is a deadbeat system. The delay-line compensator generates a polynomial in y, which has zeros in the complex-frequency plane. The lumped-parameter system has poles which represent its resonant frequencies and time constants. The correct deadbeat design is one which has a delay-line y-plane zero coincident with each lumped-parameter s-plane pole.

These all-zero designs have advantages over the conventional Chebyshev design, in which the useful frequency band is filled with poles which distort the function and produce ripples in both gain and phase. Outside of the useful frequency band the Chebyshev function is quite smooth and well behaved although near zero in magnitude. In the Posicast design, the useful frequency band is devoid of singularities and, consequently, the function has very uniform and constant gain throughout the bandwidth. It is only in the stop band or at the very high frequencies that there are ripples in the gain function, but these occur at frequencies where the gain is so low that the variations in the gain are negligible.

In both the all-zero design, and in systems with feedback around transmission lines and lumped-parameter elements, the system transference is a function of both y and s.

To distinguish the two kinds of poles and zeros as well as the two kinds of frequency planes, we will call all poles and zeros due to lumped-parameter elements black ones, and all poles and zeros due to distributed-parameter elements red ones. The red-pole frequencies and the black poles are plotted in the s plane, and the black-pole frequencies and the red poles are plotted in the y plane. A function of y and s can be expanded in partial fractions in s, and the residues evaluated by distance products. A black-pole residue in the s plane is the distance product from all of the black singularities in the s plane times the distance product from all of the red singularities in the y plane. A red-pole residue in the s plane is equal to minus $1/T$ times the distance product from all of the black singularities in the s plane, times the distance product from all of the red singularities in the y plane, with an extra pole at the origin of the y plane.

The improvement in performance can be observed in the frequency response as well as in the impulse response. The frequency response is the product of the function along the $j\omega$ axis of the s plane and the function along the unit circle of the y plane.

A complex-zero signal generator for testing systems delivers a repetitive signal consisting of two successive step functions, like the integral of two successive impulses. The ratio of amplitudes and the time spacing are adjustable. The signal generator is connected to a 2-pole system, and the output is observed on an oscilloscope. The amplitude and pulse timing are varied until the oscilloscope shows a deadbeat response. The signal generator has produced an infinite column of zeros in the s plane, and the deadbeat response means that two of these zeros are coincident with the two system poles. The resonant frequency and damping or time constants can be read directly from the dials of the complex-zero signal generator. This can be used for complex systems, in which each transient component in turn is nulled.

The complex-zero generator can be used to measure the co-ordinates of each s-plane pole independently of the others for an actual system. It can measure both resonant frequencies and damping, and time constants. Two complex-zero generators can be ganged together in such a manner that the output signal is the convolution of two double-step functions, which is a 4-step function with a particular relationship between the steps. These two generators can then be used to measure simultaneously the co-ordinates of four different poles in the s-plane. These poles can have any combination of complex and real co-ordinates.

Digest of paper 59-917, recommended by the AIEE Basic Sciences Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, Wash., June 21-26, 1959. Published in AIEE *Communication and Electronics*, Jan. 1960, pp. 786-95.

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Analog Division Circuit

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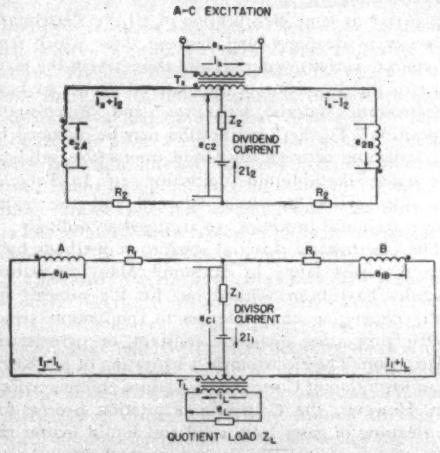

Fig. 1 (*left*). Cross-field reactor division circuit.

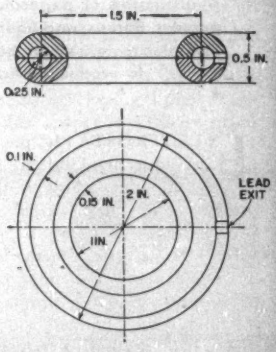

Fig. 2 (*right*). "Hollow doughnut" core of cross-field reactor.

A COMPLETELY MAGNETIC circuit which produces an alternating voltage output directly proportional to the quotient of two d-c input signals has been studied. The output is also directly proportional to the alternating voltage used for excitation, which, thus, may be employed as a multiplier input signal; otherwise, a regulated a-c supply is required. The circuit contains no semiconductors and is relatively insensitive to changes in the properties of the magnetic cores. It has the advantages of simplicity, ruggedness, ability to operate under severe environmental conditions, and reasonable accuracy for a wide range of the divisor and dividend control signals.

The circuit (Fig. 1) consists of two similar cross-field reactors, A and B, input transformer T_X, output transformer T_L, excitation voltage e_X, d-c control sources $2I_1$ and $2I_2$ in series with impedances Z_1 and Z_2 respectively, and load impedance Z_L. Resistances R_1 and R_2 represent winding resistances.

A "hollow doughnut" core shape (Fig. 2) is suitable for construction of the cross-field reactors. A circular winding is inserted in the annular window, and a toroidal winding is put on after assembling the two halves of the core. The magnetic intensity produced by one winding is perpendicular to the magnetic intensity produced by the other winding, throughout the volume of the core. The location of the annular window is such as to maintain approximately uniform core cross-sectional area with respect to the annular winding.

Using isotropic core material having a sharply saturating magnetization characteristic with small coercive force, the division mode of operation has been analyzed by an approximate method. Ideally, the no-load output voltage is equal to the excitation voltage times the quotient of the two control currents, and has the same frequency and wave shape as the excitation. The circuit is a 4-quadrant divider: reversal of I_1 or I_2 (but not both) will reverse the phase of the load voltage.

The conditions under which the division mode of operation is obtained are:

1. The excitation voltage is less than about 35% of the saturation voltage of both cores.
2. The magnetic intensity produced by the dividend current is less than about 80% of the magnetic intensity produced by the divisor current, which should be at least five times larger than the coercive force.
3. The load impedance is large, such that the load current is very small compared with the divisor current.
4. The divisor control circuit impedance Z_1 is large, so that the induced second harmonic current is small compared with the divisor current.
5. The voltage drop due to exciting current in the winding resistance is small relative to the excitation voltage.

Experimental data was obtained at an excitation frequency of 400 cps. The core material is a General Ceramics Corporation ferrite, "Ferramic H." With a constant value of excitation voltage, and a 10-to-1 range for both the divisor and the dividend currents (100-to-1 range for the quotient), the no-load output voltage measured the quotient with an accuracy of $\pm$ 6%.

Digest of paper 59-668, recommended by the AIEE Magnetic Amplifiers Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer and Pacific General Meeting, Seattle, Wash., June 21-26, 1959. Published in *AIEE Communication and Electronics*, Nov. 1959, pp. 606-12.

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Electrostatic Deposition Processes

KARL SITTEL

A discussion of deposition processes involving powder, fibrous, and liquid materials. It is shown that electrostatics can be adapted successfully to production-line techniques.

ELECTROSTATIC phenomena, in spite of being as old as mankind, are less understood than other phenomena. This is due to the extreme complexity of the fundamental mechanism involved.

A particle may obtain a charge by contact electrification (triboelectric effect), by contact with a metal electrode kept at a high potential, or by exposure to unipolar ions in a corona discharge. The latter two methods have obtained wide significance for the production of charges in industrial processes.

In an electrostatic field, charged particles will experience forces acting upon them. Also, in a nonhomogeneous field, noncharged dielectric particles will move into or out of the denser field depending on the dielectric constant of the particle and its surrounding medium.[1]

CLASSIFICATION OF PROCESSES

THERE ARE MANY PROCESSES to which the principle of electrostatics has been applied. In most cases, electrostatics is used to propel and to deposit finely divided material. Only in a few cases has an attempt been made to attribute some specific effects to electrostatics.

For example, electrostatics has been used for the economic recovery of a valuable catalyst,[2] or for the separation of material with different electrical properties as in the conversion of hydrocarbons.[3] In this process, the degenerated catalyst flocculates and precipitates under the influence of a corona discharge while the active catalyst under the same conditions is unaffected. In still another process,[4] the corona discharge itself has been found to have a catalyzing effect on the chemical reaction which may be considered as a specific effect.

Table 1. Classification of Electrostatic Processes

Main Group	Subgroup	Major Industrial Process
Electrostatic Material Separation	Solid from solid Solid from liquid	Mineral separation
	Solid from gas Liquid from solid	Cottrell precipitation process
	Liquid from liquid	Dehydration of oil
	Liquid from gas	Cottrell precipitation process
Electrostatic Deposition	Solid (powder)	Electrostatic printing
	Solid (fibrous or elongated particles)	Electrostatic flocking, electrostatic matting
	Liquid	Electrostatic painting

Eliminating the specific actions of electrostatics, one may arrive at some classification of all the electrostatic processes by distinguishing between those which tend to separate various materials and those where the main object is the deposition of the material. Hence we have "Electrostatic Material Separation" and "Electrostatic Deposition." Further classification may be obtained by distinguishing between solid-solid interaction, solid-gas interaction, liquid-liquid interaction, etc. In Table I, this classification has been adopted and the major known technical processes are arranged accordingly.

The electrostatic material separation methods have been discussed lately by Ralston.[1] Many separation processes have been worked out for the mineral industry depending on differences in conduction, triboelectric properties, dielectric constant, or pyroelectric polarization. The electrostatic dehydration of oils based on an invention of Cottrell has obtained commercialization. However, the Cottrell precipitation process for the cleaning of gases from solid and liquid matter became the most widely accepted method. It is being used in the cement, carbon black, sulphuric acid, steel, and gas industries and predominantly for the cleaning of flue gases from the large boilers used in the generation of electricity.

This article, however, shall be devoted to the second group, "Electrostatic Deposition," and to a discussion of the processes which have grown to major proportions.

DEPOSITION OF POWDER

CONTRARY TO THE SEPARATION PROCESSES, these processes emphasize the deposition of the material. The fact that electrostatics may play a role to separate the material from a carrying gas, or other conveying means is of minor importance. Important is the way the material is deposited and the means by which deposition is effected. These means may be essentially different depending upon whether the material which has to be deposited is a powder, fibrous and elongated particles, or a liquid. The case of a powder shall be discussed first. In most cases, it will be an expensive resin powder which may be used to bind some fibrous material together. Mechanical and economical means to apply a fine powder without loss are rather insufficient. Electrostatic deposition achieves a control over the distribution of powder which no other means can produce. While this can be applied to distribute binding powder within any fibrous structure in order to fix the loose fibers,

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ne most striking example to be discussed here is the electrostatic printing process.[5] This process has become very important because of its automation possibilities and high-speed performance.

In this process, a conductive plate is coated with a photoconductive insulating material. Such a material possesses the property of being a very good insulator when kept in the dark but becoming conductive as soon as it is exposed to light. The surface of the coating is given a uniform electric charge by conventional means. Then the plate is exposed to the image of whatever shall be reproduced using a camera, projection apparatus, or making a contact exposure. By this exposure, the plate areas are discharged in accordance with the light intensity thereby creating an electrostatic latent image on the plate coating. To make this image visible, one has to apply some ink or powder to the charged areas. At this point, the electrostatic deposition of the printing powder takes place.

The toner, a resin powder containing a pigment, is brought together with comparatively coarser material. By the triboelectric effect (contact electrification) the electroscopic toner will charge oppositely to the coarse carrier material and adhere to it. The coarse medium acts as charger as well as carrier material. The coarse particles fall through the chute without sticking and land on the electrostatic image bringing the electroscopic powder in close contact with the charged areas onto which it is precipitated in accordance with the potential distribution. The carrier particles are removed by gravity taking along the surplus toner. After the carrier particles are removed from the deposition zone, they are replenished with toner and reintroduced into the deposition cycle.

The image is transferred onto a paper backing by applying a corona charge to the back of the paper. At the same time, the charge polarity is chosen opposite to the charge of the electroscopic powder so that the powder is sucked onto the paper.

This system is called Xerography.[1] Xerography employs a selenium-coated metal plate, a pigmented powder for ink, and a transfer to paper for the final print. A side view of a continuously operating printer is shown in Fig. 1. The center of the machine is a cylindrical drum which has been removed in this picture. This drum carries the selenium surface. The projection mechanism can be seen on top of the machine exposing the freshly charged drum surface to the image. The drum rotates counter-clockwise and carries the image into the area where one can see a chute through which the toner powder falls onto the drum by gravity. The charged toner attaches to the image and the surplus falls off by gravity aided by a special electrode conforming to the drum surface. The drum then passes close to a paper strip running over two rollers to be seen on the right side of the drum. Here the paper is charged by a corona wire from the back, causing the transfer of the powder image. The paper is fed through a fusing section where the resin part permanently fixes the image and then emerges as a finished print on the left side of the machine. Various versions of this machine are on the market today making up to 24-inch-wide prints from microfilms, or reproducing single copies of opaque or translucent originals. Due to the high quality reproduction and the possibility of working from cathode ray tubes reproducing from "on" or "of" line signals at a rate of 84,000 words per minute, the process lends itself to high-speed computer output recording. Many other applications of this method are under consideration.

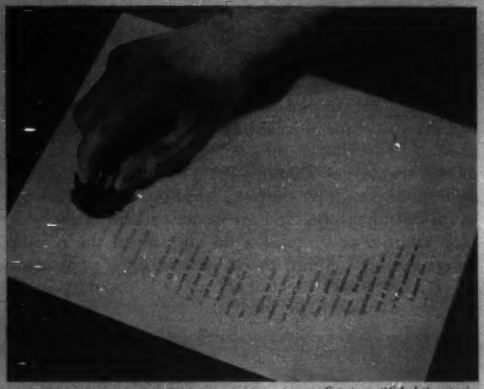
In another development, the transfer of the powder image has been eliminated by developing a photosensitive paper.[6] This "Electrofax" paper is ordinary paper

Courtesy Haloid Xerox, Inc.

Fig. 1. Xerox copyflow continuous printer model no. 1, interior view.

with a thin flexible white coating of special zinc oxide in a resin binder. The paper is sensitized by submitting the zinc oxide to a corona discharge. Then the paper is exposed by any of the conventional photographic procedures. This forms a latent electrostatic image in a similar way as described for the selenium. The image is then developed by applying a pigmented resin powder carrying a positive charge. The powder is attracted and held by the negatively charged image areas. Finally, the powder image is fixed by melting the resin powder so that it fuses to the paper surface to produce a durable light-fast image.

Young and Greig[6] use a magnetic brush, formed from iron powder held by a magnet, to apply the toner which adheres to the iron powder by the triboelectric effect. The magnetic brush carries the powder close to the charged areas of the print and in the resulting high electrostatic field the toner is precipitated onto



Courtesy RCA Laboratories

Fig. 2. Photosensitive paper for electrostatic dry photo process. Photo illustrates application of the toner by means of iron filings held by a small magnet.

the electrostatic image. This is shown in Fig. 2 where a hand method of developing the prints is depicted.

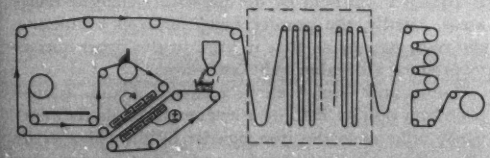
At the present time, the art of electroprinting is in its beginning stage but has already proven that it has many beneficial features which make it an art in its own right.

DEPOSITION OF FIBROUS PARTICLES

IN CONTRAST to the powder deposition, fibrous and elongated particles pose a considerably bigger problem. The difficulties are due to some inherent properties of fibrous materials. Elongated particles are able to align in an electrostatic field with respect to their length direction. Comparable to small dipoles, they may form strings in much the same way as one experiences the magnetic field lines with iron filings. Furthermore, fibrous materials cause in many cases a felting action because of many small irregular subfibers which produce mechanical interaction between the fibers. While these properties are a hindrance in many cases, they have been effectively made use of in other applications. First, the electrostatic flocking operation shall be discussed as a striking example.

ELECTROSTATIC FLOCKING

THE COATING OF PAPER, textiles, or plastic material poses a technical problem in many ways. The material to be coated first receives a fine layer of adhesive. Then the coating material is dropped through vibrating sieves or is blown against the still tacky adhesive. This process has a number of shortcomings. The penetration of the fibers into the adhesive is normally insufficient and, consequently, the durability of the coating limited. Also, the uniformity and alignment of the fibers is extremely hard to control.



Courtesy Bahr-Manning Co.

Fig. 3. Diagrammatic sketch of an electrostatic coating unit.

Electrostatic forces not only streamlined this process but also improved the end product so that today surface coated material finds many applications. The first use of electrostatic coating in the United States was made in 1926 in the manufacture of sandpaper. A description of the method of electrocoating fabrics was given by J. O. Amstuz in 1941.[7] The coating takes place between two flat electrodes to which a high a-c potential is applied (Fig. 3). The fibers or the crushed mineral particles are carried over the lower electrode on a conveyor belt. The base material runs parallel to the lower conveyor with its adhesive film facing down. As soon as the particles enter the electrode spacing, they are polarized, and in the case of fibers, align themselves with the field. According to their conductivity and the conductivity of the conveyor material, the particles will charge up and shoot into the adhesive. If the viscosity of the adhesive is right, the particles will be well embedded through the electrostatic force, aligned and densely deposited due to the polarization effect, and uniformly distributed because of the repelling action of equally charged particles.

The use of alternating potentials is quite important in this process. As the fibers are held firmly in place once they are deposited, reversing the field does no harm to the deposit. On the contrary, the deposit of the fibers becomes much denser on an a-c field. The only requirement is that the charging and deposition time be identical with the half period of the a-c potential. In this case, one may say the deposition field is in phase with the depositing mechanism. Under such conditions, densities of 250,000 to 300,000 fibers per square inch can be obtained, all fibers standing perpendicular to the surface. The alternating potential has yet another favorable effect on the deposition mechanism: it prevents the so-called tree formation. This is the aligning of a series of particles end to end like little magnets bridging the gap between the electrodes.

The process, of course, has to be set up for each individual coating process, and the process parameters such as the frequency of the a-c field, the field strength, the feeding speed of the backing material, the feeding speed of the particles, and the adhesive, have to be tuned to each other. If this is done, the possible effects are manifold. For instance, one may produce a pattern by simply applying the adhesive in pattern form before depositing the coating material as it is shown in Fig. 4.

Today, small as well as large coating machines are available, and the field is gaining momentum. Electrocoating is used in various industries such as the toy industry, decorating industry, packing industry, in

Courtesy Behr-Manning Co.

Fig. 4. Patterns produced by the electrocoating process.

sound engineering, etc. The coating of plastics with metallic powders is a coming field.

ELECTROSTATIC MATTING

IN THE ELECTROCOATING and flocking operation, the coating is deposited on a base material. A mat does not have such a base support but the fibers form a self-supporting structure after removal from the forming conveyor. The fiber length is normally a magnitude larger than those used in the flocking operation. Besides this, the fibers are crisscrossed and randomly distributed instead of being aligned in the direction of the electrostatic field. A flocked surface is as deep as the length of the fibers, all the fibers standing side by side. For a mat, the thickness is given by the number of fibers piled on top of each other. The fibers are held together by a binder, fixing fiber to fiber at their cross points, while in a flocked surface the fibers are embedded with one end in a thin layer of adhesive.

The textile industry developed the carding process to work vegetable and animal fibers. The fibers emerge from the carding machine as a loosely assembled fibrous membrane. Crisscrossing a number of membranes on top of each other will form a mat.

One idea describes electrostatic forces acting on fibrous membranes as they are running off a carding machine in order to upend individual fibers from the horizontal plane of the membranes, making them suitable for interlocking with other membrane layers.[8]

For certain fibers and applications such as glass mats used for reinforcing plastics, the carding process is not suitable because of the fragility of the fibers, which when damaged lose their reinforcing property. Consequently, other methods have been developed based on air distribution systems. In such a system, the fibers have to be guided through chutes or ducts where the fibers tend to stick to the walls, accumulating and forming clumps which spoil the even distribution of the mat.

Electrostatics and fibers have been mentioned together at least as far back as 1936 and probably before. One method[9] which is concerned with the deposition of fibrous material is described as follows: Two ingredients are fed into the machine, one a fibrous and the other a suitable binding material of a sticky character. The fibers are blown in by blowers and the binding particles by spray guns. One ingredient is charged positively and the other negatively. The description reads: "During the mixing or coating process, the charges on the particles tend to become neutralized. Thereafter the mixed or coated particles are moved into a settling zone by the combined gas streams where the mixed or coated particles are subjected to an electric field which charges and deposits them on a belt in the form of matting or a web."

It is important in the matting process that the actual charge of the fibers is large as compared with the polarization due to the electrostatic field. Only under these conditions will the fibers start to mat. This surface polarization is due to the formation of an ionized water film on the surface of dielectrics.[10] Fig. 5 shows how the relative humidity of 60% produces polarization of glass

Fig. 5. The influence of humidity on the behavior of glass fibers in a deposition field. (*Left*) Relative humidity above 65%; (*right*) relative humidity below 40%.

Courtesy Ransburg Electro-Coating Corp.

Fig. 6. Deposition of a paint spray in an ionizing field. Object to be painted is on ground; regular spray nozzles are used.

fibers which mat as soon as the humidity drops below 40%. However, the humidity must not be too low in order to prevent back corona originating on the mat surface which stops the further controlled build-up of the mat.[11,12]

DEPOSITION (SPRAYING) OF LIQUID

To improve the quality of material or to impart certain characteristics to a material and in this way obtain a combination of properties which otherwise cannot be obtained, the art of coating was developed. Coating implies the presence of a base material to which a coat of other material essentially different from the base material is applied. In some cases, this is accomplished by means of an intermediate film of adhesive as in the flocking operation. There short-length fibers or mineral particles are stuck with one end into the adhesive film forming a more or less unidirectional particle layer. Or it is just the application of a uniform film of liquid material like paint, varnish and so on. This leads to the very well-developed art of electrostatic painting.

One of the most active fields in the development of electrostatic processes is production-line spray painting. The problem here is threefold. First, the percentage of paint which is lost in regular spray painting is high and increases painting costs considerably. Second, the amount of spray required per article is left to the judgment of the operator which again results in overspray and loss of valuable paint. Third, there is the problem of eliminating the overspray which requires elaborate exhaust and waterfall eliminators. Electrostatic painting has come a long way in solving most of the problems and aiding in streamlining production-line painting processes and improving the finished product at the same time.

How does it work? Fig. 6 shows the standard approach. The paint is atomized by an air gun which directs the paint into an ionizing field set up between the article to be painted and an array of thin metal bars acting as corona source. The paint spray is charged due to the ion bombardment and deposited on the grounded article which moves on an overhead conveyor.

Fig. 7 shows a different approach. Here the paint is atomized by a modified air gun the nozzle of which is separated from the rest of the mechanism by long insulated extension tubes. These tubes are also the support for the corona rings which are concentrically arranged needle points. The article is suspended from an overhead conveyor and rotates around its axes while passing the spray nozzles. The article (which, of course, has to be a conductor) is placed on ground potential. Between the corona points and the article, a high electrostatic field is produced in which a stream of ions initiated on the corona points flows toward the article. In this ion stream the atomized paint droplets are charged and directed toward the target by electrostatic forces. To increase efficiency, a number of corona wires can be strung behind the articles. They are placed on the same potential as the corona points of the spray gun. As a result of this arrangement, all the field lines are forced to end on the article and any spray missing the target will be reversed in the strong opposing field and finally end up on the article. This method permits even complex equipment to be painted in automatic operation.

A further development was the introduction of electrostatic atomization. In this process, the major variables such as atomizing air pressure and exhaust air currents essentially responsible for overspray are entirely avoided. The spray head consists essentially of a hollow, cone-shaped or flat tray (Fig. 8). The paint is metered at a constant rate to the inner rim of the head and rotation of the head spreads the material uniformly over its inner surface. In this way, the paint flows evenly

Courtesy Ionic Electrostatic Corp.

Fig. 7. Spray nozzles with attached corona rings.

to the outer edge. A strong electrostatic field is set up between this sharp outer edge and the article to be coated. Under the influence of the extremely high nonhomogeneous field at the edge of the head, the paint is drawn apart and atomized and the charged droplets follow the field lines toward the article. Because of the extremely fine spray produced in this way, gravity has little influence on the spray pattern and a complete electrostatic deposition is achieved. The spray pattern may be varied by changing the size and shape of the spray head to suit the specific article to be painted. Since all of the paint leaving the spray head is deposited, no other removal system is required. The process is truly a production-line process independent of the skill of an operator. In most cases, the efficiency is in the high 90's and, in some instances, exceeds 99%. As a direct result, this process gives 25–75% more pieces per gallon than any conventional spray finishing system.

The process can be applied to metallic articles. Nonmetallic articles require, at least temporarily, a metallic backing. As to the atomization, most coating materials which can be readily atomized can be applied. Enamels, lacquers, and varnishes, whether conducting or nonconducting, are handled satisfactorily. Conveyor speeds from 3 feet per minute to 800 feet per minute are being used.

The latter process as well as the others described result not only in increasing efficiency but also in improving the painting or coating job itself.

CONCLUSION

THE DISCUSSION of the various deposition processes involving powder, fibrous, and liquid materials has shown that electrostatics can be successfully used in production-line processes. The action obtained in a deposition field depends on the electrical properties of the precipitate. In general, the field which acts on the charge of the particle also causes electrical polarization of the particle. By controlling the surface properties of the particles, one may be emphasized over the other, leading to different actions in the deposition field. In all processes, it is important that uncontrollable mechanical actions on the particles are eliminated. This presents the problem of how the particles are brought into the deposition field. This may be accomplished by intermediate coarser carrier materials or by conveyor belts or other conveying means. In many cases, the conveying means is an airstream. However, airstreams introduce many uncontrollable factors. It is also of importance whether deposition takes place under the influence of an ionizing or nonionizing field.

Greater deposition forces may be developed in an ionizing field. However, nonionizing fields are preferable where larger quantities of materials, especially highly insulating materials, are to be deposited.

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Courtesy Ransburg Electro-Coating Corp.

Fig. 8. Electrostatic atomizing disc replacing air spray gun.

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165-Ton Reactor Vessel

The 165-ton reactor vessel for New England's first nuclear electric generating station was shipped recently from The Babcock & Wilcox Company's Boiler Division works in Barberton, Ohio. Measuring 27 feet long and 13 feet across, the vessel arrived at its destination, the Yankee Atomic Electric Company plant site, at Rowe, Mass., during the week of February 8.

A specially built depressed flatcar three times the length of an ordinary freight car carried the "atomic furnace" on its 900-mile journey. Four railroads teamed up to move the cargo over its carefully charted route—the Erie; New York, New Haven & Hartford; Boston and Maine; and Hoosic Tunnel & Wilmington.

A Symmetrical Component Approach to Load Balancing

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FELLOW AIEE

In 3-phase systems, an unbalanced load may tend to distort the voltages at its terminals. A method for correcting this condition by means of an additional unbalanced load connected between an appropriate pair of phases is described.

AN UNBALANCED LOAD connected to a 3-phase system tends to distort, or unbalance, the voltages at its terminals. This is because the unsymmetrical currents which are drawn by the unbalanced load involve unsymmetrical impedance drops in the source impedances. Thus, while the generated voltages at the ultimate source may be quite well balanced, the unbalanced impedance drops from the ultimate source to the terminals of the unbalanced load will result in distortion of the symmetry of the voltages at the load terminals. In power system practice, it is customary to minimize the effect through making an effort to balance the load on various distribution feeders.

In low-voltage circuits, such as those fed from potential transformers involving relays and instruments, or in the testing laboratory, reconnecting the load for better distribution between phases is not always practical. This is particularly true when one item of load, or burden, is inherently unbalanced and cannot be changed. An illustration of this sort is a positive-sequence or negative-sequence voltage filter. In such cases, an additional unbalanced load may be connected between an appropriate pair of phases so that the total load, or burden, will be completely balanced. This article describes a method of approach, based on the method of symmetrical components, for the determination of the correct magnitude of the additional unbalanced burden and the selection of the appropriate phase pairs. The method is illustrated by using an arbitrarily selected problem.

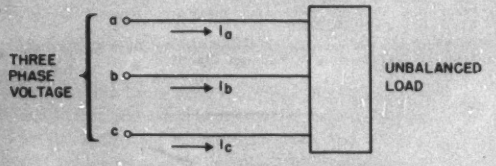

Fig. 1. Circuit diagram with unbalanced load.

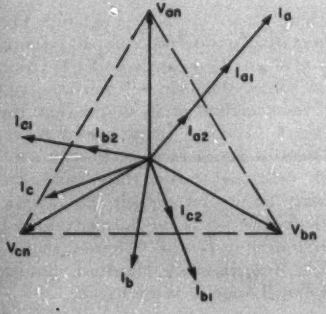

Fig. 2. Phasor diagram for Fig. 1.

AN UNBALANCED-BURDEN PROBLEM

FIG. 1 shows an unbalanced load connected to a source of 3-phase voltage at terminals *a*, *b*, and *c*. The unbalanced load represented in block form could represent the total burden of numerous relays and instruments supplied from capacitance-coupled potential devices on which it is desired to balance the total load.

Fig. 2 shows three arbitrarily chosen unbalanced currents—I_a, I_b, and I_c—in the phase leads. It is presumed that they will be measured values, both in magnitude and phase angle, when, by whatever suitable means, the voltages at terminals *a*, *b*, and *c* are arbitrarily maintained at balanced values as shown by the phase-to-neutral voltages, V_{an}, V_{bn}, V_{cn}, together with the dashed-line delta triangle of voltages.

SYMMETRICAL COMPONENT ANALYSIS

THE UNBALANCED CURRENTS, as illustrated in Fig. 2, are analyzed by symmetrical-component methods into their positive- and negative-sequence components. This analysis yields the positive-sequence current phasors I_{a1}, I_{b1}, and I_{c1}, as well as the negative-sequence components I_{a2}, I_{b2}, I_{c2}. The method of obtaining the positive- and negative-sequence components of currents, as shown, is adequately covered in various texts and will not be repeated here.

It is apparent from Fig. 2, and from a general knowledge of symmetrical components, that if the negative-sequence current phasors could be eliminated, then the load would be balanced, as shown by the positive-sequence current phasors. However, a premise to this problem is that the nature of the unbalanced load, or burden, is such that the negative-sequence components

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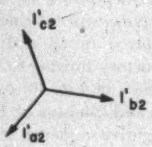

Fig. 3. Negative-sequence phasors opposite to those of Fig. 2.

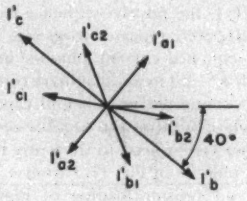

Fig. 4. Current phasors for phase bc loading.

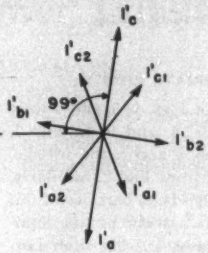

Fig. 5. Current phasors for phase ca loading.

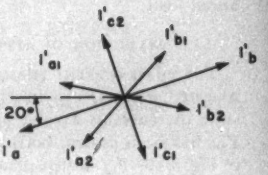

Fig. 6. Current phasors for phase ab loading.

cannot be eliminated from the connected load. It follows, however, that if equal and opposite negative-sequence components could be drawn by an auxiliary load connected in parallel with the presently illustrated unbalanced load, then the additional negative-sequence components of the additional load would completely neutralize the negative-sequence components of the presently connected load insofar as the total circuit is concerned. Thus, what is needed is an additional set of negative-sequence currents, as illustrated in Fig. 3, which are equal and opposite to the negative-sequence components shown in Fig. 2.

PHASE-TO-PHASE LOADING

A CLUE to a method of approach to be used in selecting a suitable phase-to-phase loading is obtained by considering the nature of a phase-to-phase fault on power systems. In the fault, there is no current in the unfaulted conductor. However, the method of symmetrical components teaches that the symmetrical component quantities are present in each phase. This is harmonized with the knowledge that there is no current in the unfaulted conductor by considering that the positive- and negative-sequence components in the unfaulted conductor must be equal and opposite and thus neutralize each other insofar as current measurable with an ordinary ammeter is concerned. Using this knowledge, the three phasor diagrams of Figs. 4, 5, and 6 are constructed.

In each of these three diagrams, the negative-sequence current phasors from Fig. 3 have been repeated. In Fig. 4, the positive-sequence current phasor, I_{a1}', was arbitrarily arranged equal and opposite to the negative-sequence current phasor, I_{a2}'. Adding the appropriate sequence components together yields two phase currents, I_b' and I_c', with $I_a' = 0$. The net currents, measurable with an ordinary ammeter, are I_b' and I_c' flowing in conductors b and c.

In Fig. 5, I_{b1}' was arbitrarily made equal and opposite to I_{b2}' for a start in constructing all three of the positive-sequence current phasors. Adding the appropriate phasors together for this figure yields phase currents I_a' and I_c', with nothing in phase b. Thus, phases a and c are involved.

In Fig. 6, the one remaining combination was used, where the positive-sequence current phasors were constructed starting from I_{c1}' arbitrarily made equal and opposite to I_{c2}'. This phasor diagram yields currents I_b' and I_a', involving phase conductors a and b.

Various angles have been indicated in Figs. 4, 5, and 6 between phasors and a horizontal reference line to be used in locating the appropriate phasors in Figs. 7, 8, and 9. The determination of these angles starts from

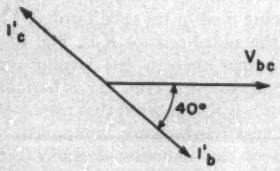

Fig. 7. Phase currents of Fig. 4 with respect to V_{bc}.

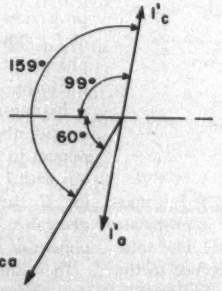

Fig. 8. Phase currents of Fig. 5 with respect to V_{ca}.

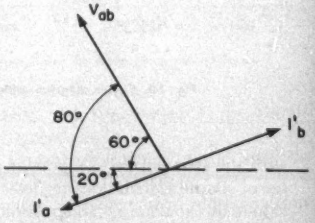

Fig. 9. Phase currents of Fig. 6 with respect to V_{ab}.

the various angular relationships shown in Fig. 2, which, in turn, depend upon the nature of the original unbalanced load.

SELECTION OF APPROPRIATE PHASES

THE PHASE-CURRENT PHASORS of Figs. 4, 5, and 6 were repeated, respectively, in Figs. 7, 8, and 9. In Fig. 7, since the currents involve phases b and c, the voltage, V_{bc}, has been drawn, borrowed from Fig. 2. Similarly, in Fig. 8, the V_{ca} voltage phasor has been borrowed from Fig. 2, since the currents involve a and c phases. Similarly, in Fig. 9, the voltage phasor V_{ab} has been borrowed from Fig. 2 because it shows the voltage for the two phases involved.

It is practical to obtain current phasors such as I_b' and I_a', Fig. 7, by using a combination of resistance and inductive loading on phases b and c. This is indicated by the 40-degree lagging angle in the diagram. Thus, the total load in Fig. 1 could be balanced by adding an appropriate load in parallel with the presently unbalanced load wherein the additional load would draw currents from phases b and c as shown in Fig. 7.

Fig. 8 does not represent a practical solution. This is because the current phasor I_c', lagging the voltage phasor V_{ca} by 159 degrees, would require a loading involving a negative resistance. This is not practical.

In Fig. 9, another practical solution is indicated, in that it is possible to utilize a combination of resistance and capacitance to produce a current I_a', leading the voltage phasor V_{ab} by 80 degrees.

SUMMARY OF RESULTS

IN FIG. 10, the solution as suggested by Fig. 9 has been adopted, for reasons to be discussed. In Fig. 10, capacitor C and resistor R are so proportioned as to demand from phases a and b the currents indicated in Fig. 9. (The imaginary conductor carrying $I_c' = 0 = I_{c1}' + I_{c2}'$ allows the details of the circuit to be harmonized

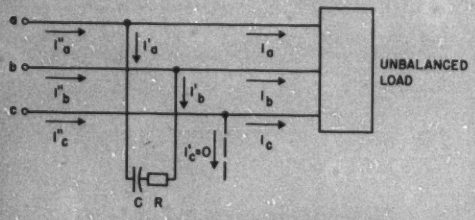

Fig. 10. Circuit diagram with added load.

with the symmetrical component concepts.) It is a matter of simple calculations to determine the appropriate values of capacitance and resistance to use. The solution suggested by Fig. 9 was used in preference to the solution suggested by Fig. 7 because it carries with it the benefit of neutralizing some of the inductive-reactance component of the presently existing unbalanced load.

In Fig. 11, balanced phase-to-neutral voltages of the supply circuit are shown in the same position as in Fig. 2. Next, the positive-sequence current phasors, I_{a1}, I_{b1}, and I_{c1}, were repeated from Fig. 2. Now, since the negative-sequence current phasors involved in I_a' and I_b' (with $I_c' = 0$ in an imaginary conductor) flowing to the series-connected resistor and capacitor of Fig. 10, completely neutralize the negative-sequence phasors of Fig. 2, there is no need to show any negative-sequence current phasors in Fig. 11. However, the additional capacitor and resistor loading of Fig. 10 involves also the additional positive-sequence current phasors of Fig. 6. These are shown in Fig. 11 as I_{a1}', I_{b1}', and I_{c1}'. Adding

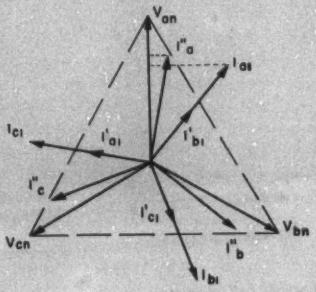

Fig. 11. Phasor diagram for Fig. 10.

these two sets of positive-sequence phasors yields the total currents I_a'', I_b'', and I_c''. These constitute a set of balanced-current phasors for the total load, which was the objective of the problem.

REVIEW OF RESULTS

AN INSPECTION of Fig. 11 reveals that the net total positive-sequence currents, I_a'', I_b'', and I_c'', are now less in magnitude than the original positive-sequence currents as pictured in Fig. 2. However, projections of the new total phase currents on their respective voltage phasors, such as the projection of I_a'' on its voltage V_{an}, reveal at once that there will be a larger energy component involved. Considering only phase a, for example, it is obvious from the picture that the in-phase projection of I_a'' is greater than the in-phase projection of I_{a1}. The same observation applies to the other two phases. The conclusion from this is that more energy in the form of heat is being used by the total burden. This is harmonious with the added resistor R in Fig. 10. A second observation is that there is less lagging component in the new total currents. This, too, is harmonious with Fig. 10 when it is remembered that the capacitor C furnishes a negative-reactance component to neutralize a portion of the inductive-reactance component of the previously assumed unbalanced load.

In summary, this method shows an over-all gain in that the problem of balancing the total burden has been solved with the additional benefit of reducing the reactive component of the burden.

An Electric Analog of Power Transistor Heat Flow

JAMES REESE W. W. GRANNEMANN J. R. DURANT

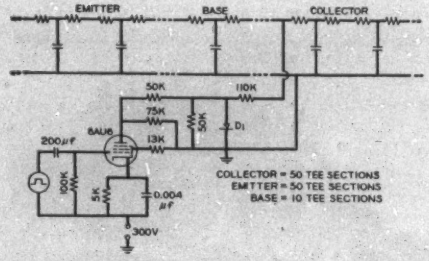

Fig. 1. Power transistor heat flow analog and current generator.

IN THE DESIGN of circuits utilizing power transistors, the maximum allowable instantaneous junction temperature is often the major limitation on the power-carrying capabilities of the circuit. Transistor failure may result if the junction temperature exceeds, even momentarily, a certain maximum value.

While the maximum safe operating junction temperature is usually given by the manufacturer, it is often difficult to determine what the junction temperature actually is under various excitation conditions. An electric analog of heat flow in power transistors can be designed to give, immediately, the temperatures throughout the crystal under a wide variety of excitation conditions. Further, the analog may be used to study ways of extending the maximum safe operating temperature.

Fourier's heat-flow equation in one dimension is analogous to the equation for voltage variation along a transmission line. By reducing the heat-flow model of a power transistor to a 1-dimensional model, one may simulate the transistor with a transmission line. To simplify construction and operation, the continuous transmission line may also be simulated with an equivalent tee-section lumped-parameter line. Such an analog, with its feed source for a rectangular pulsed input, is shown in Fig. 1.

An analog was constructed for the Minneapolis Honeywell type *H6* transistor. The variations in crystal temperatures with time, for a rectangular pulsed input, are shown in Fig. 2. Note that with the analog, one may observe the temperature at any point in the crystal. The only temperatures easily obtainable experimentally are the junction and mounting base temperatures. Some of the other advantages of the analog, as compared to experimentally obtained data, are:

1. Changes in the physical geometry (size of base fin, collector termination, size of emitter and collector, etc.) are easily made on the analog.
2. Ambient temperature effects may be noted on the analog without ovens or refrigeration.
3. Changes in transistor characteristics with age and environment which necessitate constant calibration for experimental data are eliminated in the analog.
4. Measurements of power input necessary to raise junction temperature to a dangerous level under various pulsed conditions can be made, with the analog, with no risk of damaging transistors.

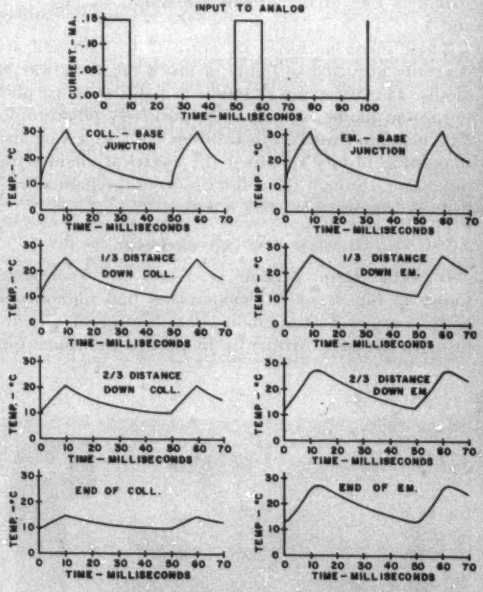

Fig. 2. Analog waveforms for rectangular pulsed input.

5. With the analog, the time required to obtain specific pulse data is greatly reduced.
6. The effect of various cooling techniques may be investigated, quite easily, with the analog.
7. In using the analog, a mathematical representation of the waveform under study is not necessary. If the waveform can be generated and applied to the analog, the temperature may be determined at any point in the crystal.

Digest of paper 59-766, "An Electric Analog of Heat Flow in Power Transistors," recommended by the AIEE Solid State Devices Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, Wash., June 21-26, 1959. Published in AIEE, *Transactions*, pt. 1 (*Communication and Electronics*), vol. 78, Nov. 1959, pp. 640-43.

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Stability in Steering Control

I. E. SUTHERLAND

With the aid of mechanical models, a study on the steering mechanisms of animals has been conducted. Comparisons are made with many of our commonly used vehicles, such as automobiles, trucks, and tractors.

MAN has long shown interest in making machines which would perform functions previously done only by living things. Sometimes the motive behind building such machines was to perform the functions better or more cheaply, and sometimes the motive was to bring about a fuller understanding of the animal function. Three machines which behave strikingly like small animals are shown in Figs. 1, 2, and 3.

These three machines are sensitive to light and are generally attracted to lights in much the same way as moths. The attraction of moths to lights is called phototropism; moths are said to be positively phototropic. The biologist's interest in tropisms has had a long and interesting history in which the electrical engineering profession, through the construction of mechanical animals, is beginning to play a part.

BIOLOGISTS AND TROPISMS

IN 1918, Jacques Loeb described an experiment, shown in Fig. 4, which demonstrates that phototropic animals are not attracted to lights because of a desire to be in the most brilliantly lit part of the room, but because they are somehow forced to face toward the source of illumination.[1] In 1954, H. F. Blum proposed a mathematical model of a phototropic animal which would face toward the source of illumination.[2] Blum named his hypothetical model *Hypotheticus loebi* in honor of Loeb.

Fig. 1. *Machina versatilis* moving towards a flashlight. Two photocell eyes are located in the black head at the top of the machine. One of the two driving wheels can be seen in center foreground; rear caster is used for support; plastic bumper senses obstacles. Powered by 10 flashlight cells in tubes in center of machine, 36 transistors enable *M. versatilis* to chase lights, squeal appealingly when it bumps something, and attempt to avoid the obstacle.[3]

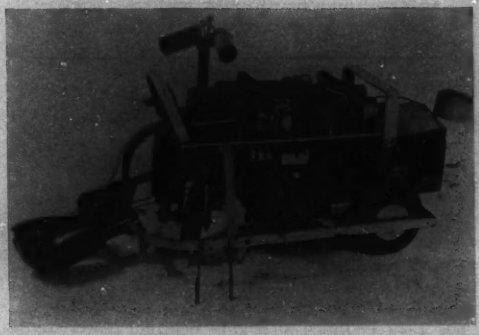

Fig. 2. Squee, the mechanical squirrel, hunts for tennis balls located underneath incandescent lights. After picking up ball in dark scoop shown at left, it goes to flashing light which marks its nest to deposit the ball. Squee's eyes are in two small cylinders forming a V. Single wheel directly below eyes both drives unit forward and turns for steering. Power comes from a power cord trailing behind or from a lead-acid battery.[3]

Using *H. loebi*, Blum was able to calculate paths which phototropic animals should take in moving around lights. The calculated paths correspond very well to the paths of live animals, even explaining the circling motion which is characteristic of moths near light bulbs.

Blum was familiar with some of the mechanical model animals which had been built. Comparing his own *H. loebi* to one of these, he said: "The relationship of this arthropod to *M. speculatrix* (Fig. 3) is not altogether clear . . ." *H. loebi* had been defined always to turn toward lights, but Blum had avoided any mention of how this was accomplished. *M. speculatrix*, on the other hand, moves toward lights, but its steering mechanism is clearly defined and is not the only mechanism which can exhibit *H. loebi*-like behavior. The relationship of *H. loebi* to *M. speculatrix* is now clear: *M. speculatrix* is a particular species of the genus typified

Essentially full text of paper awarded first prize in the AIEE District 14 Student Prize Paper Contest. Recommended for publication by the AIEE Educational Publications Committee.

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by *H. loebi*. The author's *M. versatilis*, shown in Fig. 1, is another such species.

TYPES OF STEERING MECHANISMS

Differential-Drive Steering. In the case of *M. versatilis*, there are two symmetrically placed driving wheels which, if driven at different speeds, make the machine turn (Fig. 1). Many common vehicles steer in this way: Caterpillar tractors or bulldozers, military tanks, rowboats, and certain large ships when maneuvering in close quarters by driving the propeller on one side forward and on the other side backward.

It is easier to obtain stable steering control in a differential-drive vehicle than in some other types of vehicles because any steering correction is felt at once throughout the entire vehicle. The rate of turn of a differential-drive vehicle is proportional to the difference between the right- and left-side driving rates, and if this difference is made proportional to the heading error, the heading error will decrease exponentially to zero. More complicated relations between the driving rates and the heading error, involving time lag or simple nonlinearities, will generally provide stable steering control by use of a single feedback path without compensation, because there is no time lag between making a change in the steering mechanism and sensing the change.

As one might expect, the control systems of differential-drive vehicles are very simple. For example, a modern military tank, which must have power steering because of its size, has no feedback loop built into its steering system. The driver, in moving his steering wheel, controls clutches which apply engine power to increase the speed of one track and decrease the speed of the other through two sets of planetary gears in the transmission.[8] The driver senses heading errors and, moving his steering wheel in proportion to these errors, closes the single feedback path involved in steering the tank.

Loeb's early work on tropisms suggested that some insects use differential drive steering. Loeb said that if in an insect one eye be more brightly illuminated than the other,

> ". . . the muscles connected with the more strongly illuminated eye are thrown into a stronger tension and if now impulses for locomotion originate in the central nervous system, they will no longer produce an equal response in the symmetrical muscles, thus turning the head and body of the animal to the source of light." [1]

If the stronger tension Loeb mentions interferes with the locomotion of one side of the animal, the animal uses differential-drive steering, but if the stronger tension tends to curve the animal's body, the turning to the source of light results from rudder action. In some species it may be hard to decide whether turning results from differential-drive or rudder action.

Rudder Steering. Most of the common vehicles in use today use a rudder or guiding wheels to provide direction control. Automobiles, trucks, children's tricycles,

Fig. 3. *Machina speculatrix* is similar to Squee in steering design except that only a single photocell is used. It can associate sound, light, and touch.[7]

and large ships all have a separate part, wheels or rudder, which pivots to provide steering. Guidance of these vehicles is customarily accomplished by using two feedback loops. For example, a truck with power steering has a mechanical feedback loop which positions its guiding wheels according to commands given by the driver, who closes a second feedback path by sensing errors in the truck's course.

In Fig. 5 is shown a schematic plan view of a rudder steering vehicle, in this case a tricycle. It is clear that $d\phi/dt = V/R$ and that $R \sin \theta = L$. For small θ, then, $d\phi/dt = K\theta$ where K is a constant proportional to the velocity V. This relation between ϕ and θ, expressed in transform notation, has been placed in the block diagrams, Fig. 6, as $G_2(s)$. $G_1(s)$ depends on the type of mechanism used to move the steering system.

If an electric motor or hydraulic cylinder is used to move the steering column, $G_1(s)$ will be of the form K/s or $K/s(s+1)$. If a single-loop system is used to

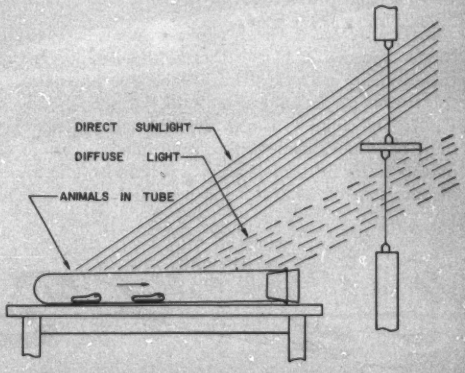

Fig. 4. The classic experiment of Jacques Loeb, which shows that phototropic insects will move from light into the shade. The insects are placed in glass tube; they move toward source of light, the window at right, even though they leave the brightly lit left half of the tube.

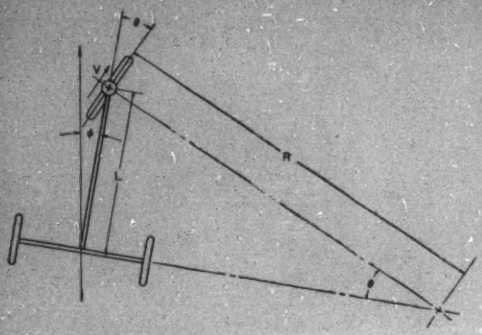

Fig. 5. Plan view of rudder steering vehicle.

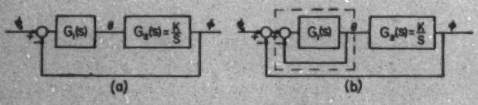

Fig. 6. Block diagrams of steering servomechanisms for automobiles: (a) Unstable single-loop system; (b) Second loop added for stability.

control the vehicle, as in Fig. 6(a), steering will be unstable. The common cure for this instability is shown in Fig. 6(b). Here a second feedback path has been added to make the part of the circuit within the dotted line have a simple constant transfer function. Thus, in an automobile with power steering, the position of the steering wheel and the angle of the front wheels are related by a constant through the use of a hydraulic servomechanism with feedback. Similarly, the position of a ship's wheel and its rudder angle correspond, even though huge engines are used to turn the rudder. If the inner loop in either of these vehicles were to fail, steering control would be lost.

Turning Heads. The 2-loop system of Fig. 6(b) is common in man's vehicles because the sense organs of these vehicles are located in their bodies. The author's conception of an animal built like this is shown in Fig. 7. This animal, named *Hypotheticus ridiculus* because of its obvious departure from nature's custom of putting heads in front of animals, would have to know the position of its front end accurately in order to steer stably, just as some measuring device must sense the θ of Fig. 6(b).

Animals which use rudder steering are built with their sense organs on the steering element; for example, snakes. The mechanical animals of Figs. 2 and 3 are also built in this way, the photocell eyes being mounted on top of the steering column. The sense organs, then, sense $\phi + \theta$, in the terms of Fig. 5, rather than just ϕ. Fig. 8(a) gives the block diagram applicable to Squee, a mechanical squirrel, expressed in the artificial variables ϕ and θ to show its similarity to Fig. 6.

Like Squee, many live animals have a connection between steering and sense direction. For example,

> ". . . if the tail in a normal shark be bent to one side the eyes of the animal move . . . in an opposite sense. On the convex side of the animal, the white of the eye is more visible in front, on the concave side it is more visible behind . . ."[3]

That is, the shark's inside eye rolls forward, ensuring that the shark may see in the direction in which it is going. Similar behavior is observed in fish. Loeb indicates that a change in the position of the head of a dog changes the tone of the muscles which control the front legs, thus making the dog proceed in the direction in which its head is facing. Horses can be controlled by turning their heads; in fact, to make a horse turn very sharply, one pulls its head far to one side. It may be that man has achieved freedom from this attachment of head position and direction of travel by standing erect.

It might be expected that in a vehicle whose driver turned with the guiding wheels, power steering could be accomplished without any feedback loop other than the driver. Fig. 9 shows such a vehicle, and although a feedback loop is provided in its steering system by the manufacturer, it is often removed by the driver.[4]

Similarity Between Squee and M. versatilis. If one watches the earth mover, shown in Fig. 9, at work, it is impossible to say whether it uses differential-drive steering or rudder-type steering. The two front wheels are powered, and it could be that they are driven at different rates, just as *M. versatilis*' wheels are in order to steer. Or it could be that the front wheels and cab are twisted sideways by hydraulic cylinders in just the same way that Squee's front wheel and eyes are moved by a motor. To find out which is the case requires examination of the machinery included in the vehicle. In the case of the earth mover, hydraulic cylinders twist the front wheels and cab for rudder steering.

Fig. 7. *Hypotheticus ridiculus*, which steers like an automobile. It is like an automobile in that its head and eyes are located on its body, just as the driver of an automobile is located in its body. *H. ridiculus* could steer by turning its front end in one direction or the other, just as an automobile steers by turning its front wheels. There would be a time lag between its starting a turn at its front end and observing the turn at its head just as there is a time lag between twisting a car's steering wheels 10 degrees and observing 10 degrees change in heading.

In trying to decide which type of steering a given animal uses, a similar difficulty arises. For example, a snail that is turning a corner may be driving harder on one side than the other, using differential-drive steering, the curve of its body merely showing where the head was previously. On the other hand, this same snail may have long muscles in its sides to curve its body, and driving uniformly underneath, make a corner. Proof of which method the snail uses depends on showing the existence of either a body curving mechanism for rudder steering, or the ability to crawl at a different rate on one side than on the other.

STEERING IN ANIMALS

ALTHOUGH proof of which type of steering the following animals use must rest on observing biological mechanisms, we can speculate on the type of steering used in some simple cases. Since snakes and earthworms can wriggle even if held away from any support, they at least have the long body curving muscles necessary for rudder-type steering. Snails probably also use rudder-type steering, although as has been shown, this is yet to be proved.

On the other hand, the animals with inflexible bodies probably use differential-drive steering. Crabs cannot curve their bodies; they must use differential drive. A lobster's head and body are fused together; when it crawls, differential-drive steering is used. Insects probably use differential-drive steering; however, this fact may be a little more difficult to determine.

Certain animals such as fish use the long body-bending muscles for locomotion, thus confusing the steering issue. For animals such as this, however, steering when coasting is clearly of the rudder type.

CONCLUSIONS

STUDY OF MECHANICAL MODELS of animals shows two contrasting steering systems in use. Examples of these two systems in vehicles, model animals, and live animals are as follows:

1. Using differential-drive steering: bulldozers, military tanks, *M. versatilis* (Fig. 1), crabs, lobsters, and probably insects.

2. Using rudder-type steering with sense organs on the rudder: some self-loading earth movers (Fig. 9), Squee (Fig. 2), snakes, worms, and probably snails.

Some study of biological mechanisms must be done before insects, snails, and some other borderline cases can be classified with certainty.

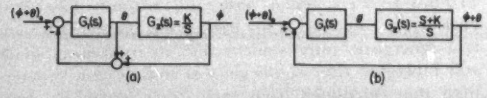

Fig. 8. Block diagram of steering servomechanism in rudder steering animals: (a) Expressed in the artificial variables of Fig. 6 to show stability; (b) Expressed in measurable variables to show single-loop character.

Fig. 9. Earth-moving vehicle whose driver turns with the front wheels. Whether it is similar to Squee, Fig. 2, or *M. versatilis*, Fig. 1, must be determined by a detailed study of the mechanism used for steering. Similarly, which method animals use for steering must be determined by a detailed study of their muscle arrangements.

Automobiles and large ships use rudder steering with sense organs on the main body. Vehicles of this type commonly use control systems with two feedback loops; animal steering mechanisms need only a single feedback path for stable operation. In building vehicles with complicated control systems, consideration should be given to animal-like mechanical systems. If simplification of control system outweighs additional mechanical complexity, use of an animal-like system will be justified.

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Jet-Driven Gas Turbine

One of the world's first jet-driven gas turbines for stationary power is expected to go on stream early this summer at the Clementville, Ky., pipeline compressor station of the Columbia Gulf Transmission Company, subsidiary of Columbia Gas Systems, Inc. The gas turbine, which is rated at 10,500 hp, was developed by The Cooper-Bessemer Corporation, Mount Vernon, Ohio, and Pratt & Whitney Aircraft Division of United Aircraft.

Electrified Fibrous Air Filters

J. W. THOMAS E. J. WOODFIN

Fig. 1. One-inch precipitator.

TWO OF THE DEVICES most commonly used to clean air of atmospheric dust are mechanical filters, frequently made of Fiberglas media, and electrostatic precipitators. For air conditioning application, neither filters nor precipitators are entirely satisfactory.

Fibrous filters are small, cheap, and have low-pressure drop, but are inefficient in removing particles as small as cigarette smoke. Electrostatic precipitators are efficient in removing cigarette smoke, but are normally too large and expensive for air conditioner application.

A third type of air cleaner, which as yet has had relatively little investigation, combines action of mechanical fibrous filters and electrostatic precipitators. These filters may be designated "electrified fibrous air filters" and consist of a fibrous media on which is impressed a direct potential field gradient. They may be made by printing conducting channels on thin Fiberglas media, or by inserting Fiberglas packing between plates of electrostatic precipitators.

Electrostatic precipitators function both by charging air-borne particles and then by collecting particles under an impressed direct potential field gradient. This is a most efficient method of operation. With electrified fibrous filters, particle charging is not quite so important. Due to presence of Fiberglas packing, particles to be collected are already close enough to surfaces so that small naturally existing charges and polarization forces are sufficient to deposit particles.

Electrified fibrous filters may be visualized as conventional parallel plate precipitators with plate spacings of a few thousands of an inch.

Tests were made of experimental electrified fibrous filters by passing cigarette smoke (about 1/2 micron diameter) through them at various known air velocities and field gradients. Efficiency was determined by sampling a portion of the influent and effluent through white "Millipore" filters, and measuring the reflectances of the resulting discolored sampling filters.

Fig. 1 shows the evaluation of one of the Fiberglas-packed precipitators, which was 1-inch deep in direction of air flow. Fig. 2 shows efficiency of this precipitator in filtering cigarette smoke as a function of superficial air velocity and impressed direct potential field gradient. Fig. 3 shows the efficiency of a similar precipitator 14.5-inches deep, tested with and without Fiberglas packing, in direction of air flow. From the figure, there is a synergistic improvement due to combining field and Fiberglas; that is, efficiency is considerably greater than that calculated from each effect separately. For example, at 200 feet per minute, efficiency with Fiberglas only is 17%; field only, 35%. With both field and Fiberglas, efficiency is 82%.

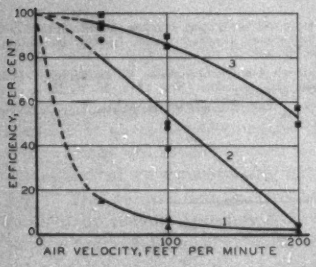
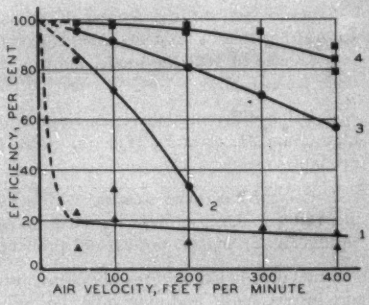


Fig. 2 (*left*). Efficiency of precipitator of Fig. 1. Curve 1—field, 5,500 volts per inch; Curve 2—field, 11,000 volts per inch; Curve 3—field, 20,000 volts per inch.

Fig. 3 (*right*). Efficiency of 14.5-inch precipitator. Curve 1—Fiberglas, no field; Curve 2—no Fiberglas, 23,500 volts per inch field; Curve 3—Fiberglas, 10,700 volts per inch field; Curve 4—Fiberglas, 23,500 volts per inch field.



Digest of paper 59-680, recommended by the AIEE Domestic and Commercial Applications Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Appliance Technical Conference, Cleveland, Ohio, May 18-19, 1959. Published in AIEE *Transactions* pt. II *(Applications and Industry)*, vol. 78, Nov. 1959, pp. 276-78.

J. W. Thomas and E. J. Woodfin are with the Whirlpool Corporation, St. Joseph, Mich.

Constant-Frequency Generator Systems

B. V. HOARD
MEMBER AIEE

IN THE PLANNING AND DESIGN of electric generation systems for aircraft there is always the need for reduction in weight, volume, maintenance, and rebuilding costs. There is also the need for improvements in performance; i.e., better voltage and frequency control and higher efficiency. A system design is important which will improve reliability by reducing unpredictable failures through fewer and more reliable parts, especially those subject to wear.

A frequency make-up generator is proposed as replacement for the existing constant-frequency generator and mechanical constant-speed drive system. In the new system, an exciter and a rotating static-type frequency changer feeds make-up or slip-frequency power into the polyphase-wound generator rotor (field) as shown in Fig. 1. The frequency (f_2) produced by shaft rotational speed and the rotor slip frequency (f_s) add algebraically to provide a constant stator output frequency (f_1). A reference frequency (f_r) which is equal to f_1, and a signal generator, provide slip frequency signals for control of frequency-changer power. The number of wearing parts will be reduced to shaft bearings. The frequency changer will be made from semiconductors which with sufficient derating, will have a long life. As a result the reliability of the new system is estimated to be considerably better than for constant-frequency generating systems now used in aircraft.

The frequency make-up generator can be built to operate all-below or below-through and above synchronous speed. A weight comparison for 60-kva systems of each type shows the following: if equal maximum-shaft operating speeds and equal centrifugal-force stresses in the rotors are maintained, then the weights of the two system types are about equal for shaft-speed variations up to 2-to-1 ratio. This speed ratio is within the requirements of most existing jet-type aircraft engines.

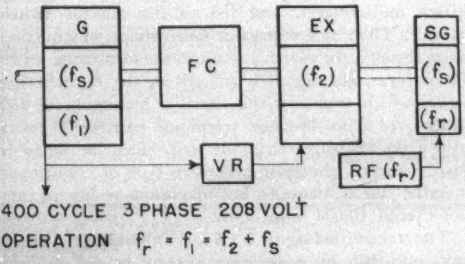


Fig. 1. Frequency make-up generator with variable-speed shaft. SG—signal generator; G—generator; FC—frequency changer; EX—exciter; RF—reference frequency; VR—voltage regulator.

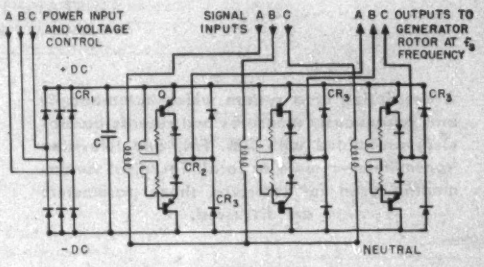


Fig. 2. Transistorized frequency changer. CR_1—input rectifier; Q—transistor; CR_2—blocking rectifier; C—capacitor; CR_3—by-pass rectifier.

The signals and controls necessary for operation below, through, and above synchronous speed are more complicated than for a system operating all-below synchronous speed. The all-below system is selected here as providing better reliability.

A small 1-kva 60-cycle generator was assembled and tested to provide "proof of principle." The static frequency changer used is shown in Fig. 2. It converts 60-cycle power to direct current, and transistors are used to invert this power to slip frequency for use in the generator rotor. In the form shown, it will supply reactive power to the generator rotor in an efficient manner. Controlled rectifiers were not yet available when these tests were made but could have been used with some circuit modifications. The tests were successful except that semiconductors with higher rating than those available were needed. However, rapid progress is being made in this field.

A comparison between a 60-kva frequency make-up system with a 60-kva brushless generator and its constant-speed drive yields the following:

1. The weight of the new system is estimated to be 15 to 20% less.
2. Volume and total length will be less.
3. The efficiency will be three to five points better.
4. Maintenance and rebuilding costs will be materially less
5. Frequency deviation for step-load changes will be reduced essentially to zero.
6. In-flight failures will be reduced and reliability improved

Digest of paper 59-773, "Constant-Frequency Variable-Speed Frequency-Make-Up Generators," recommended by the AIEE Air Transportation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, Wash., June 21-26, 1959. Published in AIEE *Transactions*, pt. II (*Applications and Industry*), vol. 78, Nov. 1959, pp. 297-304.

B. V. Hoard is with the Boeing Airplane Co., Seattle, Wash.

Automatic Logging of AM, FM, and TV Transmitting Station Parameters

GUSTAVE EHRENBERG
ASSOCIATE MEMBER AIEE

A description of a system which automatically and continuously measures and records parameters associated with AM, FM, and television transmitters—remote or local. Technical fundamentals used for recording these parameters are discussed.

THE periodic logging of data required by the Federal Communications Commission (FCC) is a routine mechanical operation. It is best performed by a mechanism, which is usually more accurate and more reliable for this kind of work than a man. In addition, automatic logging of parameters gives the trained, reasoning engineer more time to devote to those jobs which can more effectively use his skill and judgment.

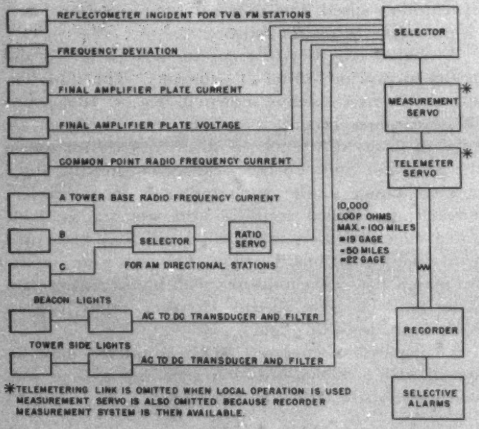

REFLECTOMETER INCIDENT FOR TV & FM STATIONS
FREQUENCY DEVIATION
FINAL AMPLIFIER PLATE CURRENT
FINAL AMPLIFIER PLATE VOLTAGE
COMMON POINT RADIO FREQUENCY CURRENT
A TOWER BASE RADIO FREQUENCY CURRENT
B
C
SELECTOR
RATIO SERVO
FOR AM DIRECTIONAL STATIONS
BEACON LIGHTS
AC TO DC TRANSDUCER AND FILTER
TOWER SIDE LIGHTS
AC TO DC TRANSDUCER AND FILTER
SELECTOR
MEASUREMENT SERVO
TELEMETER SERVO
10,000 LOOP OHMS MAX. = 100 MILES =19 GAGE =50 MILES =22 GAGE
RECORDER
SELECTIVE ALARMS
*TELEMETERING LINK IS OMITTED WHEN LOCAL OPERATION IS USED MEASUREMENT SERVO IS ALSO OMITTED BECAUSE RECORDER MEASUREMENT SYSTEM IS THEN AVAILABLE.

Fig. 1. Block diagram of system.

Station policy and other intangibles may weigh significantly when management decides whether or not to install the automatic logging equipment. These factors are different for all stations, and beyond the scope of this article. However, general industry has found it most profitable to use such mechanisms for typically routine, repetitive tasks. The broadcast industry will find it so, too.

Transmitting parameters usually recorded are:

1. Final amplifier plate voltage
2. Final amplifier plate current
3. Common point r-f current
4. Amplitude ratio to tower base r-f currents (for pattern indication of directional array).
5. Phase angle between tower base r-f currents (for pattern indication of directional array).
6. Frequency deviation
7. Reflectometer incident
8. Tower beacons and navigation lamps

COMMERCIAL PACKAGES AVAILABLE

Several different packages of equipment are available (see appendix for details). Their applications are for: (1) Remote AM station with directional array; (2) Consolidated AM station with directional array; (3) Remote AM or FM or television station—omnidirectional; (4) Consolidated AM or FM or television station—omnidirectional; and, (5) Minimum system (similar to 4).

SYSTEM DESCRIPTION

VOLTAGES from the various parameters, proportional to their values, are converted into low direct voltages or direct millivoltages, and fed to the selector switch (Fig. 1). Then each voltage or millivoltage, in sequence, feeds through the switch and on to the measuring servo. From there, the signal is placed on the telemetering servo, which transmits the signal a maximum of 100 miles over a no. 19-gauge telephone pair, or 50 miles over a no. 22-gauge telephone pair. Since the signal is direct current, the least expensive type of continuous metallic pair is adequate, but maximum resistance cannot exceed 10,000 loop ohms.

The transmitted signal is 1.5 to 3 milliamperes, turned into millivolts by a dropping resistor at the receiver. The receiving recorder then takes each millivolt signal in proper sequence and prints it on the chart, each with its own distinctive identifying color and symbol. Once

Essentially full text of paper CP60-60 presented at the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960. Recommended for publication by the AIEE Broadcasting Committee.

Gustave Ehrenberg is with the Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.

each revolution, the selector switch in the receiver is sychronized with the selector switch in the transmitting unit.

There are eight selective high- or low-alarm points which can be wired to any recorder point at the customer's discretion. Two alarm points can be used to bracket a parameter reading with a high and a low alarm.

As many as 15 different variables—parameters—can be recorded in sequence in multicolor on the 11-inch-wide strip chart at the rate of one point each 30 seconds.

The automatic logging system will accept direct voltage in any of the following standard ranges: (1) 0 to 10 millivolts, (2) 0 to 2 volts, (3) 0 to 8 volts, (4) 0 to 1 volt, (5) 0 to 5 volts and (6) 0 to 10 volts.

If zero center scales are desired or required, these voltage ranges can be suppressed.

COMPONENT DESCRIPTION

Measuring Servo in Transmitting Unit. This unit uses a bridge circuit to supply a standard variable millivoltage to null-balance the incoming signal (Fig. 2). The bridge is powered by a Zener-diode voltage supply, accurate to 0.1%. A retransmitting slidewire, also powered by a Zener supply, gives an electrical signal to the telemetering servo input. The servo is accurate to 0.25%.

Ratio Servo in Transmitting Unit. This servo accepts two voltages: one from tower *A*, and the second from tower *B* or *C* in sequence (Fig. 3). The tower *A* voltage is servo-balanced against a Zener voltage *Z*. Tower *B* voltage is brought to the retransmitting slidewire, mechanically ganged to the first slidewire.

$XA = Z$

$X = \frac{Z}{A}$

$XB =$ Output voltage

Substituting $\frac{Z}{A}$ for X,

Output voltage $= \frac{Z}{A} B = \frac{B}{A} Z$

Z, being a constant, can be disregarded, and the servo position is proportional to B/A.

The output voltage is delivered via the selector switch to the measuring servo with an accuracy of 0.25%.

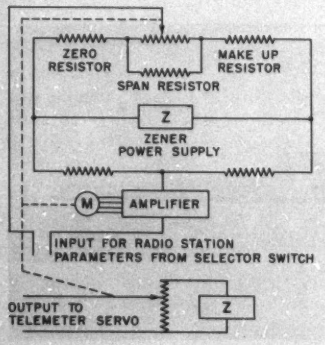


Fig. 2. Measuring servo in transmitting unit.

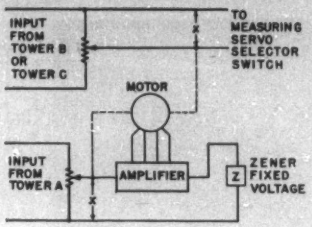


Fig. 3. Ratio servo in transmitting unit.

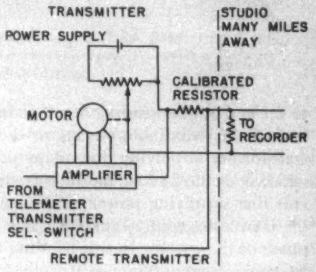


Fig. 4. Telemeter servo in transmitting unit.

Telemeter Servo in Transmitting Unit. The telemeter servo transmits a milliamperage proportional to an incoming millivoltage (Fig. 4). A null balance must be achieved between the incoming millivoltage and the outgoing milliamperage passing through a calibrated fixed resistor in series with the transmission line. The milliamperes through the resistor gives millivolts. When the system is not in balance, the servo amplifier drives the rheostat on the power supply to increase or decrease the voltage until the proper milliamperage is transmitted to give a balance. Obviously, this makes the telemetering system entirely independent of power-supply voltage fluctuations, and also entirely independent of transmission-line resistance change as long as it does not exceed 10,000 ohms. Line leakage is the only effect not compensated for in this type of telemetering system. On a good line, the system is accurate to 0.25%.

Servo-Operated Recorder Used for Receiving Unit. A synchronous vibrator is used to "chop" direct current into pulses going through an input transformer that is center tapped to produce alternating current (Fig. 5). The alternating current is applied to the grid of the first voltage amplification stage. Note that this alternating current is in phase with the 115-volt line supplying current to the transformer of the power amplifier. The synchronous vibrator has a small permanent magnet that is operated by an electromagnetic coil energized by the power transformer filament winding.

The amplifier consists of three standard-resistance capacitance-coupled voltage-amplification stages. The output stage is actually a phase discriminator. The grids of the two sections of the output tube are tied together and are operated from the output of the last voltage stage. The plates of the tube are supplied with alternating power. The cathodes of the tubes are connected

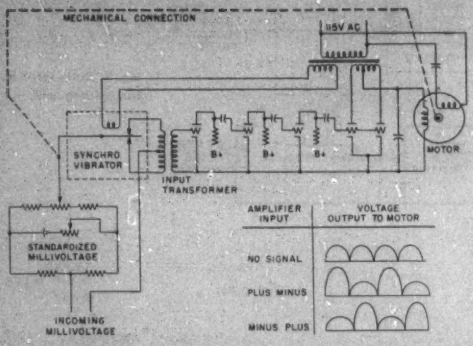


Fig. 5 (*left*). Servo-operated recorder used for receiving unit.

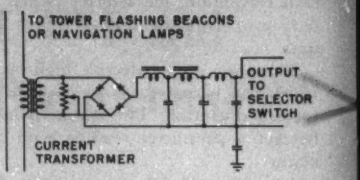


Fig. 6 (*right*). Tower-light transducers.

to the end of one winding of a 2-phase motor. The other end of this winding connects to the center tap of the transformer supplying the plate voltage. The second winding of the 2-phase motor is energized from the 115-volt line supplying power to the amplifier. This winding is in series with a capacitor. The capacitor shifts the phase of the current in this winding by 90 degrees. This 90-degree current-phase shift is needed for operation of a 2-phase motor. One field should be 90 electrical degrees from the other. The phase of the current coming from the amplifier will be either in phase with the power-line current, or 180 degrees out of phase because the synchronous vibrator remains in phase with the power line.

Operating Conditions. 1. If there is no voltage input to the amplifier, the grids of the output tubes will not be energized and the output tubes will pass current since they are not at cutoff. However, this current will be 120 cycles d-c as shown. The servo motor will then tend to move in opposite directions for each half-cycle, and will not move.

2. If the input to the amplifier is plus-minus, the grids of the output stages will be plus (+) when one tube fires, and minus (—) when the other tube fires. Therefore, the output will look similar to the second wave form since one set of waves has grown, and the other set has diminished. The motor will move in the direction designated by the large waves.

3. If the input to the amplifier is minus-plus, the grids of the final output stage will be positive (+) when the opposite tube plate is positive (+), or when the other half-cycle appears. Therefore, the output wave will be similar to the third diagram shown, or 180 degrees from the first set of half-cycles. The motor will turn in the opposite direction.

Fig. 7 (*left*). Light panel with input adjustments for a consolidated station.

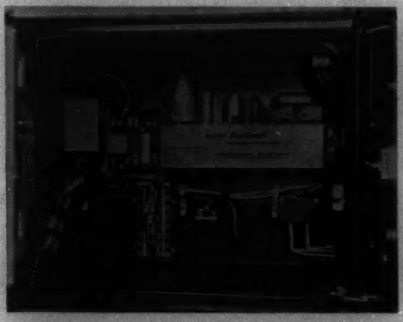


Fig. 8 (*right*). Inside of recorder case.

Fig. 9 (*left*). Receiving recorder chassis swung out showing selective alarm adjustable alarm switches.

Fig. 10 (*right*). Front of remote transmitter unit showing servo amplifiers.

There is a capacitor in parallel with the winding of the motor energized by the amplifier. This capacitor tunes the circuit to 60 cycles, and instead of a half-wave pulse, the oscillations will give full 60-cycle a-c sine wave which can be seen on an oscilloscope. The capacitor, in series with the other motor winding energized by the 115-volt power lines, tunes this winding for minimum impedance. This winding draws 11 watts to 15 watts (approximately) from the power line. The winding energized from the amplifier draws approximately 1 to 2 watts. This is sufficient to supply a rotating field to the motor. The amplifier has an amplification factor of 1 million. About 4 microvolts across the input will start turning the servo motor. The recorder pen as well as a series of adjustable cams which trip switches for alarms, are operated by this servo system.

Alarm System in Recorder. The alarm system is a selective type, so that only the alarm connected with the point being measured can operate. This allows each variable to operate anywhere over the instrument's 11-inch scale without affecting any other point. The cam alarm switches are energized in sequence through a selector switch. A timing mechanism allows the instrument to come to balance before applying power to this circuit. Relays are dropped out to give an alarm light by the cam switches if the cam settings are exceeded. A manual reset button picks up the relays, which are then held in by a holding contact.

TRANSDUCERS AT TRANSMITTER

Tower-Light Transducers. The transducer is a current transformer whose primary is placed in series with one line of the tower-light cable (Fig. 6). The output is across a variable resistor. The resistor produces an a-c voltage which is rectified by a full-wave bridge before it passes through two choke capacitor filters and finally through an r-f filter. The smoothing filter will take a 40-cycle per minute pulsing of tower beacons and give only a 1% flicker to the pen motion of the recorder. The same transducer is used for tower side lights and beacon lights.

Voltage and Current Transducers. Voltage transducers are generally in the transmitters especially if remote control is used. They are voltage dividers to reduce voltage to a low value at ground reference. Current transducers are shunts, usually in the ground side of circuits, and of sufficient size to give a voltage if remote control is used.

Fig. 11. Transmitter showing front panel swung out. Note input selector switches. Space is available for extra switches for automatic control.

Transducers for Large Current Measurement at High Voltage Above Ground Reference. A saturable reactor, powered by the 120-alternating-voltage power line, isolates the high-potential current electrically. The reactor requires a full-wave rectifier and filters, plus voltage division, to reduce the input to an acceptable level for the logging equipment.

Monitors for Frequency, Reflectometer Incident, etc. The monitors include a meter circuit for output reading. Generally, there is provision made to substitute an external meter for a 10% resistor. A calibrated resistor in the range of the external meter resistance can be inserted instead, to give an adequate millivoltage for either microamperes or milliamperes in the meter circuit. The logging equipment uses this millivoltage directly. This millivoltage is generally at ground reference, and where it exceeds 100 volts, an isolation servo with ground reference transmission is required

CONCLUSION

THE AUTOMATIC LOGGING of AM, FM, and television transmitting stations is an accomplished fact. Systems

Fig. 12 (*left*). Back of transmitter unit showing ratio, measuring and telemetering servos, input adjustments, navigation lamp calibrating equipment, and input terminal blocks.

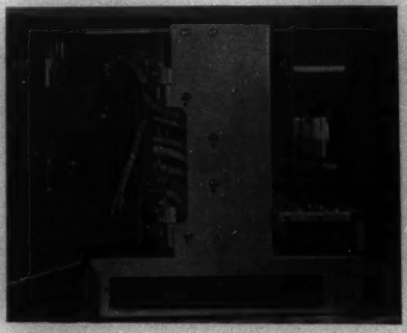


Fig. 13 (*right*). Side view of transmitter showing amplifiers, servos, and input adjustments.

are presently operating in stations WTOP and WMAL in Washington, D.C., and at KFI in Los Angeles, Calif.

Data gathered from the WTOP installation are being submitted by the National Association of Broadcasters (NAB) to the FCC to secure an FCC ruling that the charts are acceptable for the official log of a station.

What has long been suspected is being proved: that improved accuracy and reliability of readings, as well as improved efficiency in the use of manpower, is making the use of this equipment mandatory in station operation.

The system and its component parts have all been designed with an eye toward the future. Provisions have been made in the remote measuring and telemetering unit for the installation of automatic control for transmitters. This control would keep the transmitter within its parameters right at the transmitter site, and so would require no long distance telemetering for control purposes. This system is available now if the broadcasting industry will specify it.

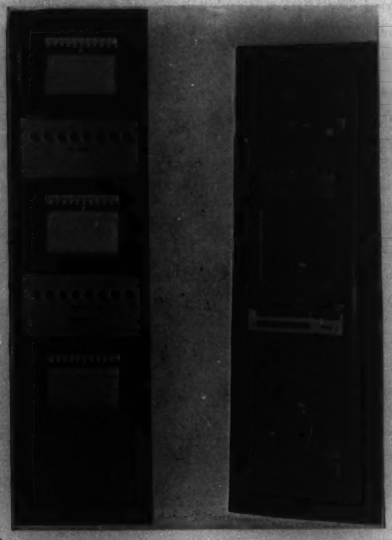


Fig. 14. Receiving instruments with alarm light panels.

Appendix

SEVERAL DIFFERENT PACKAGES of equipment are available, all for relay rack mounting. Their components are:

1. *Remote AM Station with Directional Array.*

A. Transmitter assembly—20-inch vertical height panel space.
   1. Measurement servo
   2. Ratio servo
   3. Telemeter servo
   4. Synchronizing apparatus
   5. R-F filters
   6. Input circuit span calibrating potentiometers

B. Receiver—15¾-inch vertical height
   1. Strip chart recorder with multipoint printout and selective alarm switches.
   2. Eight-alarm lamp panel—3½-inch vertical height

2. *Consolidated AM Station with Directional Array*

A. Multipoint strip chart recorder with measuring circuit and selective alarm switches.

B. Eight-alarm light panel—3½-inch vertical height.

C. 10½-inch vertical height panel containing:
   1. Ratio servo
   2. R-F filters
   3. Input circuit span calibration potentiometers

3. *Remote AM or FM television station—Omnidirectional*

A. Transmitter assembly—20-inch vertical height panel space.
   1. Measurement servo
   2. Telemeter servo
   3. Synchronizing apparatus
   4. R-F filters
   5. Input circuit span calibration potentiometers

B. Receiver
   1. Multipoint strip chart recorder with selective alarm switches.
   2. Eight-alarm lamp panel—3½-inch vertical height.

4. *Consolidated AM or FM or television station—Omnidirectional*

A. Multipoint strip chart recorder with measuring circuit and selective alarm switches.

B. Eight-alarm light panel—3½-inch vertical height

C. 10-½-inch vertical height panel containing:
   1. R-F filters
   2. Input circuit span calibrating potentiometers

5. *Minimum System (similar to no. 4)*

On all of the equipment described, included as standard is a series of calibrating precision rheostats so the customer's parameters can be brought to within the spans of the measuring system by the turn of a dial. In this system the calibrating rheostats are deleted. This was done to provide a minimum expense package for the smallest stations. Station engineers are required to put in their own equipment (the calibrated voltage-dividing resistors) to bring all of their parameters to the required millivolt span of the measuring system.

Systems no. 1 and 2 would not be used for FM and television stations because these stations do not have directional antenna arrays.

Please mail back your membership survey card promptly.

INSTITUTE ACTIVITIES

AIEE Winter General Meeting Attended by More Than 5,000 Persons

Ross Photo

DIGNITARIES at the Winter General Meeting were: (*left to right*) J. H. Foote, AIEE president; J. F. Fairman, winner of the Edison Medal; and C. E. Eble, president of Consolidated Edison Company of New York, who was the principal speaker at the general session.

NEW YORK CITY was again host to the AIEE Winter General Meeting, held January 31-February 5, 1960, at the Statler-Hilton and Sheraton-Atlantic Hotels. Total attendance was 5,186. In 112 technical sessions, 491 papers were presented.

Among the social events held were an informal tea on Sunday afternoon, a smoker on Tuesday evening, and a dinner-dance on Thursday evening.

Inspection trips were made to the Bell Telephone Laboratories, Bergen Generating Station of the Public Service Electric & Gas Company, Anaconda Wire and Cable Company, Consolidated Edison's Astoria Generating Station, Ford Motor Company's Mahwah, N. J., Plant, Brookhaven National Laboratory, Consolidated Edison's Indian Point Nuclear Generating Plant, New York International Airport, and many other important industrial locations in the New York area.

R. T. Weil, Jr., chairman of the Winter General Meeting Committee, presided at the general session, held Monday afternoon, February 1.

AIEE President J. H. Foote presented a brief address, "Beginning Our Fourth Quarter-Century," the text of which is given in this issue, p. 263.

The John Scott Award was presented to Dr. D. A. Lyon, Woodbridge, Conn., scientist and consulting engineer, for his invention of a method for producing the first useful optical coating for the reduction of light reflections. The presentation was made by Curtiss Pritchard, of the City Trust of the City of Philadelphia, administrators of the award.

Presentation of the AIEE Prize Paper Awards, as announced on p. 151 of the February issue of *Electrical Engineering*, was made by Mr. Foote, assisted by W. R. Harris, chairman, AIEE Prize Awards Committee.

The Edison Medal presentation ceremonies were next on the program. A. C. Monteith described the history of the Medal, H. C. Forbes outlined the career of the medalist, and Mr. Foote made the presentation to J. F. Fairman, AIEE past-president and vice-president of the Consolidated Edison Company of New York, who made a brief acceptance speech (see pp. 278-82).

Candidates Named

The Nominating Committee announced candidates for president, for vice-presidents of the odd-numbered Districts, for treasurer, and for three members of the Board of Directors, as reported in the March issue, p. 235. They are as follows: president—C. H. Linder; vice-presidents—C. E. Gaylord (District 1), R. J. Weil, Jr. (District 3), F. W. Bush (District 5), S. C. Wright (District 7), H. A. Carlberg (District 9), A. W. Rauth (District 11), H. A. Criley (District 13), and P. G. Wallace (District 15); directors—R. B. Gear, C. T. Hatcher, and C. T. Pearce; treasurer—W. R. Clark.

The keynote address, "Russian Power Developments and Some Implications for the United States," was delivered by C. E. Eble, president, Consolidated Edison Company of New York. The text of this address may be found on pp. 266-69 of this issue.

More than 100 technical sessions on a large variety of subjects were held throughout the week. The Safety Committee sponsored a symposium on grounding for

BESIDE the AIEE Winter Meeting attendance chart are: (*left to right*) Howard Rothstein of Brooklyn, N. Y., and Rosalind Soodak of the Bronx, N. Y., both students of the City College of New York, and R. T. Weil, Jr., chairman of the general committee for the Winter General Meeting.

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RECIPIENT of the John Scott Medal, Dr. D. A. Iyon (center), Woodbridge, Conn., scientist and consulting engineer, receives congratulations from D. C. Rubel (left), vice-president of the City Trusts of the city of Philadelphia, which administers the medal. J. H. Foote (right) is national president of the AIEE. Mr. Rubel made the presentation of the medal during the opening general session of the AIEE Winter General Meeting.

safety, in addition to a session in which temporary paralysis following "freezing" to a wire, field treatment of electric shock cases, and fibrillating currents were discussed. The Man-Machine Integration Committee sponsored papers on use of the SAGE computer for training and analysis of performance of SAGE system operators, automatic maintenance operation in an electronic telephone central office, and use of an electronic data-processing system for making military operational decisions. A number of interesting papers on electrical engineering education were presented in two sessions sponsored by the Education Committee. Topics covered included the public schools in relation to electrical engineering, the AIEE as an educational catalyst, secondary school education, trends in undergraduate curricula, industry and advanced education, education of the electrical engineering teacher, education of electrical engineers for professional careers, and graduate electrical engineering education in the United States in 1959.

Communication

A wired-memory translator with shared access, transmission problems in time-division switching networks for automatic telephony, and the numerical-graphical method in the design of multiterminal switching circuits were some of the topics covered in two sessions on communication switching systems sponsored by the Communication Switching Systems Committee.

In the field of communication theory, a symposium on "Parallel Computation of the Nervous System—Reliability through Redundancy" was held, with participation by scientists from the Research Laboratory of Electronics and Lincoln Laboratory of the Massachusetts Institute of Technology and a scientific representative from the University of Illinois.

The Data Communication Committee sponsored a session on capabilities of the telephone network for data transmission. An evaluation of the telephone message plant for data transmission and a presentation of data-phone-customer results were two topics that received emphasis. A paper on a high-speed (105,000 bit per second) data-transmission system was presented.

Two sessions were held on wire communications, one of which was devoted entirely to the *E6* voice repeater. The other session was given over to applications on the Union Pacific Railroad, and an all-transistorized trunk carrier system.

A session on telegraph systems heard papers on a freight car report sorting system; a step-driven digital magnetic recorder; a high-capacity teletypewriter terminal set; and a report on recent advances in printing telegraph apparatus. Also included were papers on advancements in the facsimile art during 1959, and the *82B1* military teletypewriter message switching system.

The Radio Communication Systems Committee sponsored two sessions. Papers on mobile telephone service; mobile radio transmission surveys; and intermodulation effects in FM and PM systems were read at the first session. The second session heard presentations on radio communication in aviation, r-f transmission line engineering, and the matching of a high-loss transmission section.

Television—color and monochrome—was the general subject of a group of papers sponsored by the Broadcasting Committee. The "Automatic Logging of AM, FM, and TV Transmitting Station Parameters" (see pp. 804-08) and the Redstone Arsenal closed-circuit educational television system were presentations highlighting the session. Also heard was a paper on dial-selected industrial television for ticket reservation facilities.

The Data and Wire Communication Systems Committees sponsored a session on data communications over wire systems. Topics included were a delay distortion simulation set; the effect of delay distortion on data transmission; and a survey of cable characteristics for data communication.

A special symposium on the International Telecommunications Union and its decennial conferences of 1959 was held on the evening of February 3 under the sponsorship of the Communication Division. F. B. Bramhall, of the Lenkurt Electric Company, was chairman. F. C. deWolf, chief of telecommunications, Department of State, and head of the United States delegation to the conferences, reviewed the origin, history, and general purpose of the Union. He stressed the role that new and emerging nations will play in the organization's future activities. Mr. DeWolf stated that eventual balance of control may pass to the Asian-African group of nations. W. E. Bloecker, of the American Telephone & Telegraph Company, spoke on the International Telephone Regulations. He stated that the reason the United States is not a signatory to the International Telephone Regulations is because this country does not want to hamper development of a dynamic art. M. H. Woodward, chief, International Division, Federal Communications Commission, reviewed some of the good reasons why the United States is a signatory to the International Telegraph Regulations. Some of the reasons are based on the need of international agreement for: (1) uniform alphabets and codes, (2) uniform word-count procedure, (3) methods and ratios of levying tolls by classes of messages, (4) uniform procedures and "Q" and "Z" signals for servicing cablegrams and radiograms. P. D. Miles, of International Radio Advisory Committee, spoke on the radio regulations and the International Frequency Registration Bureau.

General Applications

A number of interesting papers were presented in three sessions sponsored by the Land Transportation Committee. Experience since 1943 with electrification of the Sorocabana Railway was described, as were the Pennsylvania Railroad class GG-1 electric locomotives and bilevel central-powered passenger equipment. Another paper discussed some of the economic trends which appear to make railroad electrification inevitable. The use of digital computers for calculation of train performance and for simulation of single-track railroad operation was outlined. In the field of rapid transit, a paper was presented on high-performance cars for the Hudson and Manhattan Railroad.

An unusual feature of the meeting was the presentation on board the *U.S.S. Argentina* of a paper describing the electrical installations of the *S. S. Brasil* and *Argentina*. Other papers sponsored by the Marine Transportation Committee discussed neutral grounding as applied to marine a-c systems and the advantages of ungrounded marine systems.

Electric heating was the topic of a session sponsored by the Domestic and Commercial Applications Committee. Calcula-

AIEE Future Meetings

EJC Nuclear Congress
New York Coliseum
New York, N. Y.
April 4-7, 1960

Southwest District Meeting*
Shamrock-Hilton Hotel
Houston, Texas
April 4-6, 1960

Electrical Engineering in Space Technology Conference*
Hotel Baker,
Dallas, Texas
April 11-13, 1960

Materials Handling Conference*
Sheraton Hotel
Philadelphia, Pa.
April 12-13, 1960

East Central and Allegheny-Ohio Valley District Meeting
Daniel Boone Hotel
Charleston, W. Va.
April 12-14, 1960

AIEE-ASME Railroad Conference*
Penn-Sheraton Hotel
Pittsburgh, Pa.
April 20-21, 1960

AIEE-ASME-IRE Automatic Techniques Conference*
Sheraton-Cleveland Hotel
Cleveland, Ohio
April 18-19, 1960

Paper and Pulp Conference*
University of Florida
Gainesville, Fla.
April 21-22, 1960

Rubber and Plastics Conference*
Sheraton-Mayflower Hotel
Akron, Ohio
April 25-26, 1960

Great Lakes District Meeting*
Pfister Hotel
Milwaukee, Wis.
April 27-29, 1960

North Eastern District Meeting*
Sheraton Biltmore Hotel
Providence, R.I.
May 2-4, 1960

AIEE-IRE-ACM Western Joint Computer Conference*
Jack Tar Hotel
San Francisco, Calif.
May 3-5, 1960

AIEE-IRE-U of V Educational Frontiers in Biomedical Engineering Conference*
University of Vermont
Burlington, Vt.
May 5-6, 1960

Spring Textile Conference*
Georgia Institute of Technology
Atlanta, Ga.
May 5-6, 1960

AIEE-IRE-EIA-WCEMA Electronic Components Conference*
Washington, D. C.
May 10-12, 1960

Farm Electrification Conference
Sheraton-Fontenell Hotel
Omaha, Nebr.
May 10-12, 1960

Appliance Technical Conference*
Leland Hotel
Mansfield, Ohio
May 16-17, 1960

Annual Cement Industry Technical Conference*
Pfister Hotel
Milwaukee, Wis.
May 17-18, 1960

AIEE-ISA-ARS-IAS National Telemetering Conference*
Mariman Hotel
Santa Monica, Calif.
May 23-26, 1960

World Power Conference
Instituto Nacional de Industria
Madrid, Spain
June 5-9, 1960

Summer General Meeting
Chalfont-Haddon Hall
Atlantic City, N. J.
June 19-24, 1960
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—April 15)

Pacific General Meeting
El Cortez Hotel
San Diego, Calif.
August 8-12, 1960
(Final date for †TP—May 10, ‡CP Syn.—May 20, CPMs— June 3)

Aero-Space Transportation Conference
El Cortez Hotel
San Diego, Calif.
August 8-12, 1960
(Final date for †TP—May 10, ‡CP Syn.—May 20, CPMs— June 3)

AIEE-ASME Engineering Management Conference
Morrison Hotel
Chicago, Ill.
September 14-16, 1960
(Final date for †TP—June 16, ‡CP Syn.—July 1, CPMs—July 11)

AIEE-IRE Industrial Electronics Conference
September 21-22, 1960
(Final date for †TP—June 23, ‡CP Syn.—July 8, CPMs—July 18)

AIEE-ASME National Power Conference
Bellevue-Stratford Hotel
Philadelphia, Pa.
September 21-23, 1960
(Final date for †TP—June 23, ‡CP Syn.—July 8, CPMs—July 18)

Petroleum Industry Conference
Skirvin Hotel
Oklahoma City, Okla.
September 25-28, 1960
(Final date for †TP—June 27, ‡CP Syn.—July 12, CPMs—July 22)

Fall General Meeting
Morrison Hotel
Chicago, Ill.
October 9-14, 1960
(Final date for †TP—June 10, ‡CP Syn.—July 21, CPMs—Aug. 5)

AIEE-IRE-EIA-SMPTE National Electronics Conference
Sherman Hotel
Chicago, Ill.
October 10-12, 1960
(Final date for †TP—July 12, ‡CP Syn.—July 27, CPMs—Aug. 5)

AIEE-IRE Nonlinear Magnetics and Magnetic Amplifier Conference
Bellevue-Stratford Hotel
Philadelphia, Pa.
October 26-28, 1960
(Final date for †TP—July 28, ‡CP Syn. Aug. 12, CPMs—Aug. 22)

AIEE-IRE-ISA Electrical Techniques in medicine and Biology Conference
Sheraton-Park Hotel
Washington, D. C.
October 31—November 2, 1960
(Final date for †TP—Aug. 2, ‡CP Syn.—Aug. 17, CPMs—Aug. 26)

Magnetism and Magnetic Materials Conference
Hotel New Yorker
New York, N. Y.
November 14-17, 1960
(Final date for †TP—Aug. 16, ‡CP Syn.—Aug. 31, CPMs—Sept. 9)

1961 Winter General Meeting
Hotel Statler
New York, N. Y.
January 29-February 3, 1961
(Final date for †TP—Oct 31, ‡CP Syn.—Nov. 10, CPMs—Nov. 25)

*Final date for submitting papers—closed

†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

Transactions and conference papers must conform to the requirements in *Author's Guide*
For a copy, write to E. C. Day, AIEE, 33 W. 39th St., New York 18, N. Y.

Schedule of AIEE General and District Meetings

MEETING DESIGNATION	NAME OF MEETING	CONVENTIONAL SCHEDULE	1960 DATE	1960 LOCATION	1960 PAPER CLOSING	1961 DATE	1961 LOCATION	1961 PAPER CLOSING	1962 DATE	1962 LOCATION	1962 PAPER CLOSING	1963 DATE	1963 LOCATION	1963 PAPER CLOSING	1964 DATE	1964 LOCATION	1964 PAPER CLOSING	INVITATIONS DATE	INVITATIONS LOCATION
GENERAL																			NEW YORK
	WG WINTER	FEB. 1ST WEEK	JAN. 31 FEB. 5	NEW YORK, N.Y.	NOV. 2 1959	JAN. 29 FEB. 3	NEW YORK, N.Y.	NOV. 1 1960	JAN. 28 FEB. 2	NEW YORK, N.Y.	OCT. 30 1961	JAN. 27 FEB. 1	NEW YORK, N.Y.	OCT. 29 1962	FEB. 2-7	NEW YORK, N.Y.	NOV. 4 1963	65	1/31-2/5 OR 2/7-2/12
	SG SUMMER	JUNE 3RD 4TH WEEK	JUNE 19-24	ATLANTIC CITY N.J.	MAR. 22 1960	JUNE 18-23	ITHACA, N.Y.	MAR. 20 1961	JUNE 17-22	DENVER, COLO.	MAR. 19 1962	JUNE 16-21	TORONTO, CANADA	MAR. 18	JUNE 21-26	LOS ANGELES	MAR. 23	69	VANCOUVER, B.C.
	PG PACIFIC	AUG.	AUG. 8-12	SAN DIEGO, CALIF.	MAY 10 1960	AUG. 23-25	SALT LAKE CITY, UTAH	MAY 25 1961		SAN FRANCISCO CALIF.		AUG. 20-23	SPOKANE, WASH.	MAY 23	JUNE 21-26	LOS ANGELES	MAR. 23	66	PHOENIX, ARIZ.
	FG FALL	OCT.	OCT. 9-14	CHICAGO, ILL.	JUNE 10 1960	OCT. 15-20	DETROIT, MICH.	JUNE 14 1961	OCT. 7-12	CHICAGO, ILL.	JUNE 8	OCT. 5-11	CHICAGO, ILL.	JUNE 7				65	HOUSTON, TEXAS
DISTRICT	D1 EMPIRE	EARLY MAY							MAY 14-18	ERIE, PA.	FEB. 13								
	D2 MIDDLE EASTERN	MAY		(SGM)					MAY 7-9	WILMINGTON, DEL.	FEB. 6								
	D4 SOUTH EAST	LATE MAR. EARLY APR.				APR. 5-7	NEW ORLEANS, LA.	JAN. 2 1961				APR. 24-26	RICHMOND, VA.	JAN. 24					
	D5 GREAT LAKES	LATE APR.	APR. 27-29	MILWAUKEE, WISC.	JAN. 27 1960	APR. 19-21	MINNEAPOLIS, MINN.	JAN. 19 1961	APR. 18-20	FORT WAYNE, IND.	JAN. 19 1962								
	D7 SOUTH WEST	LATE MAR. EARLY APR.	APR. 4-6	HOUSTON, TEXAS	JAN. 4 1960				APR. 30 MAY 2	ST. LOUIS, MO.	JAN. 30								
	D11 EAST CENTRAL	EARLY MAY							MAY 23-25	TOLEDO, OHIO	FEB. 21	MAY 7-9	COLUMBUS, OHIO (TENTATIVE)	FEB. 8	MAY 5-7	DETROIT, MICH. (TENTATIVE)			
	D12 NORTH EASTERN	EARLY MAY	MAY 2-4	PROVIDENCE, R.I.	FEB. 1 1960	MAY 17-19	HARTFORD, CONN.	FEB. 16 1961	MAY 9-11	BOSTON, MASS.	FEB. 8 1962	MAY 14-17	PORTSMOUTH, N.H. OR PORTLAND, ME (TENTATIVE)	FEB. 13					
	D13 SOUTH CENTRAL	LATE MAR. EARLY APR.				APR. 5-7	JOINT WITH D4 NEW ORLEANS LA.	JAN. 2 1961				APR. 24-26	JOINT WITH D4 RICHMOND, VA.	JAN. 24					
	D14 ALLEGHENY-OHIO VALLEY	APR. OR MAY	APR. 12-14	CHARLESTON W. VA.	JAN. 13 1960				MAY 14-18	JOINT WITH D1 ERIE, PA.	FEB. 13								
EASTER			APRIL 17			APRIL 2			APRIL 22			APRIL 14			MARCH 29				

Schedule of Special Technical Conferences

1960	*Conference and Location	Sponsors
May 5-6	Educational Frontiers in Biomedical Engineering—University of Vermont, Burlington, Vt.	AIEE-University of Vermont
June 21-22	Standards and Electronic Measurements—National Bureau of Standards Laboratory, Boulder, Colo.	AIEE-IRE-NBS
Oct. 5-7	Extra-High-Voltage Cable—Mark Twain Hotel, Ithaca, N. Y.	AIEE
Nov. 9-11	Power Industry Computer Application—Chase Hotel, St. Louis, Mo.	AIEE
Dec. 11-14	Eastern Joint Computer—Hotel New Yorker, New York, N. Y.	AIEE-IRE-ACM
1961		
Jan. 9-11	Reliability and Quality Control—Bellevue-Stratford Hotel, Philadelphia, Pa.	AIEE-IRE-ASQC
Feb. 16-17	Solid-State Circuits	AIEE-IRE-University of Pennsylvania
Mar. 20-24	Nuclear Engineering Congress—Chicago, Ill.	AIEE-ASME-EJC Members-AIME Mgr.
April 11-12	Materials Handling—Chicago, Ill.	AIEE
April 18-20	Cement Industry—Sheraton-Cadillac Hotel, Detroit, Mich.	AIEE
May 1-2	Farm Electrification—Kentucky Hotel, Louisville, Ky.	AIEE
May 9-11	Western Joint Computer—Ambassador Hotel, Los Angeles, Calif.	AIEE-IRE-ACM
May 23	Fractional Horsepower Motors—Biltmore Hotel, Dayton, Ohio	AIEE
June 26-30	Aero-Space Transportation—Bellevue-Stratford Hotel, Philadelphia, Pa.	AIEE
Sept. 14-15	Engineering Management—Hotel Roosevelt, New York, N. Y.	AIEE-ASME
Sept. 17-20	Petroleum Industry—Jung Hotel, New Orleans, La.	AIEE
Oct. 9-11	National Electronics—Sherman Hotel, Chicago, Ill.	AIEE-IRE-EIA-SMPTE

*For earlier conferences, see "AIEE Future Meetings" on p. 311

tion of electric heating load and determining heat losses in residences were discussed by W. R. New and E. E. Linden, respectively. Also presented were papers on economics of heat pumps and heat storage as applied to residential heat pumps.

Three papers were presented under the sponsorship of the Production and Application of Light Committee. Subjects covered included integrated lighting and air-conditioning systems, acceptance and use of higher lighting levels, and voltage-temperature life testing of fluorescent ballast insulation systems.

Industry

Storage batteries and the general topic of electrical grounding as related to underground corrosion and cathodic protection were the subjects of two sessions sponsored by the Chemical Industry Committee. Characteristics of nickel-cadmium sealed cells, aircraft storage batteries, lead-acid storage batteries in telephone service, and a constant-voltage battery charger were some of the topics with which the session on storage batteries was concerned. Papers on the effect of electrical grounding systems on underground corrosion and cathodic protection; and on the grounding, bonding, and cathodic protection of pipeline pumping stations roused general interest at the other session.

The Feedback Control Systems Committee sponsored six sessions on various aspects of control systems. These aspects covered the following: feedback control theory; reliability and the systems concept (a panel discussion); ideas for solving control systems (a panel discussion); control system components; and two sessions on nonlinear control systems.

A "Planning-for-Growth" session discussed the effect of economics on system planning and the use of the digital computer in industrial power system design. This session was sponsored by the Industrial and Commercial Power Systems Committee.

In the field of industrial power rectifiers, there were 10 presentations. Silicon and germanium rectifier equipment received emphasis. A report on progress in high-power rectifier technology and a discussion of mechanical rectifier definitions are worthy of note.

A session on automation systems in metal industry discussed automation for sinter plants and servo control for synchronized conveyors. Advanced electric systems for application to metal industry processes was also presented. The session on electric systems for metal industry was devoted mainly to rectifier power supply applications.

The burgeoning field of industry control came under the scrutiny of four papers. Topics included arc suppression techniques and devices; d-c magnetic crane hoist control for a-c powered cranes; and a study of an engine-generator control system.

Instrumentation

Among subjects discussed in a session sponsored by the Indicating and Integrating Instruments Committee were thermal voltage converters capable of making accurate voltage measurements up to 30 mc, a transistorized footage counter for the paper industry, and an astatic a-c/d-c comparator with a wide frequency range.

A session on special instruments and measurements covered the role of a standards laboratory in a missile plant, fundamental properties of matter as related to wire tension, and determination of external inductances of closed conductors by means of an electrolytic tank. In addition, a bibliography on ground resistance and potential-gradient measurements was discussed.

Two papers on multiplexing were given at a session sponsored by the Telemetering Committee. One paper discussed multiplexing principles and the other covered the development and application of time-division multiplexing equipment for data transmission on an electric power system. Also described were a current-balance telemetering transmitter for pilot-wire applications and a pulse-duration telemetering system for industry.

Both analog and digital data-handling techniques were covered in a session sponsored by the Recording and Controlling Instrumentation Committee. Papers were presented on design and performance characteristics of a high-speed wide-chart recorder, a power line transient recorder, and a solid-state digital computer system for electric load monitoring.

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WINNERS of AIEE Prize Awards presented during the Winter General Meeting are: (*seated, left to right*) V. S. Thomander and R. C. MacIndoe, Newark, N. J.; N. R. Schuh, Lima, Ohio; R. M. Hubbard, Seattle, Wash.; Kien Chuang and L. F. Kazda, Ann Arbor, Mich.; (*standing, left to right*) T. Sommer, Bronx, N. Y.; T. W. Liao, Pittsfield, Mass.; G. E. Adams, Schenectady, N. Y.; M. G. Poland, Portland, Oreg.; F. J. Trebby, Spokane, Wash.; R. F. Estoppey, Newark, N. J.; and F. J. Mullin, Pasadena, Calif.

Power

Numerous subjects in the power field were covered in a total of 32 technical sessions. The Transmission and Distribution Committee sponsored five sessions, one of which was related to switching surges and transients. Included in a session on extra-high voltages were a group of papers on the various aspects of the General Electric Company's Project EHV. Discussed in a session on distribution systems were planning through optimized design, economic analysis, and application of capacitors to distribution feeders. Transmission line economics and design were among the subjects covered in a session on towers, poles, and conductors. In another session, measurement of strength of insulators, wet flashover test methods, electric stress grading of insulator strings, and radio interference studies were described.

The first of three sessions sponsored by the System Engineering Committee covered a variety of subjects, including short-range peak-load prediction, use of labor force statistics on estimating loads, and principles of economic dispatching for power system operators. Another session covered methods of calculating transmission losses as well as hydrothermal economic scheduling. The third session was devoted to digital computer solutions of such problems as turboalternator resynchronization, line-to-ground and 3-phase short circuits by the matrix method, and single phase-to-ground faults.

The Power Generation Committee sponsored two sessions, the first of which covered some of the aspects of generation planning. Load and capacity models for planning by simulation were described in one paper. Determination of generator installation dates by means of simulated reserve margins was the subject of another paper. Announcement of plans for a future round-table discussion on power station automation was made by D. M. Santer, Westinghouse Electric Corporation. In another session, a minimum excitation system for generator regulation systems was described, as was a simplified method for determining a transfer scheme on station auxiliary busses. New energy sources were discussed in two papers, one giving a recent history of thermoelectric and mechanical conversion of solar power.

In a session sponsored jointly by the System Engineering and Power Generation Committees, a bibliography of load and

STUDENT PRIZES were awarded at the Winter General Meeting to: Robert Allington (center), first place winner, and R. C. Sommer (*left*), second place winner. Congratulating the students was J. H. Foote, AIEE president.

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frequency control literature from 1922 to 1957 was described by J. Preminger of the Israel Institute of Technology. In addition, a report on application of probability methods to generating capacity problems and a panel discussion on this subject were presented by the AIEE Probability Applications Working Group.

In five sessions sponsored by the Rotating Machinery Committee, numerous topics of interest in this field were discussed. Papers related to various phases of testing included reports on evaluation of very-low-frequency testing, puncture hazard of d-c testing of large machines, d-c testing of machine windings, accelerated voltage endurance tests, and impulse testing of a-c machines. In a session devoted primarily to commutation design, a basis for inductance calculations was described, as were digital techniques. Spring-engaged magnetic clutches and electromagnetic friction clutches were discussed from the point of view of characteristics and application. Among other topics covered were analysis of solid-rotor machines, voltage harmonics of salient-pole generators, unbalanced loading of turbine-generators, and the calculation of stray-load losses in d-c machines.

In a session sponsored by the Relays Committee, two papers on transistorized phase-comparison relaying were presented. The first paper was concerned with the principles and circuit; the second described the application principles and all testing, subsequent to design testing, considered necessary to check the equipment under actual system conditions. The Relays Committee also sponsored another session in which pilot-wire protection of transmission lines and prevention of subharmonic ferroresonance in coupling-capacitor potential devices were discussed. Also presented was a bibliography of relay literature for 1957-58.

The Rotating Machinery and Relays Committees jointly sponsored a session featuring papers on induction motor protection, thermal relationships in an induction motor, equivalent circuits of asynchronous and canned motors, and the pull-in criterion for reluctance motors.

Standards and revisions of standards on a-c power circuit breakers were among the important topics discussed in sessions sponsored by the Switchgear Committee. Included were proposed American Standard definitions (C37.3), revision of standard on rating structure (C37.4), revision of standard method of determining values of a sinusoidal current wave and a normal frequency recovery voltage (C37.5), revision of standard test procedure (C37.9), and standard application guide (C37.10). The effect of current chopping in circuit breakers on networks and transformers was described in two papers. Other subjects included field tests on a 115-kv vacuum interrupter switch and mechanical loadings on circuit-breaker bushings.

The Substations Committee sponsored a symposium on extra-high-voltage substations. In a session sponsored jointly with the Switchgear Committee, subjects described were use of rod gaps for substation protection, insulation co-ordination of circuit breakers during operation, minimum volt-time characteristics for power circuit breakers, and automatic line transfer equipment for supervisory systems.

Three sessions were held under the sponsorship of the Transformers Committee. One of these sessions was devoted to insulation testing of specialty transformers, particularly with regard to the proposed AIEE test procedure. Other sessions included papers on ground-current measurements during transformer impulse tests, pseudo-final voltage distribution in impulsed coils and windings, Permalex—a new insulation system, and studies of insulating oil in new and used transformers.

The Substation and Transformers Committees together sponsored a session which included two papers on audible noise in power transformers. Also presented was a paper on a 400-mva bulk power substation as well as one on a mobile test unit designed to bring factory testing to power transformer repair shops.

Telemetering applications and operating experience on a large power system were discussed in one of three papers presented at a session sponsored by the Power System Communications Committee. Other topics covered were neutralizing chokes for telephone lines entering power stations and operation of a power-line carrier system during sustained line faults.

The Protective Devices Committee sponsored a group of five papers on lightning arresters. Among the topics considered were application for protection of multiline substations, protection of high-voltage stations, a thermal approach to the analysis of arrester operating duty, problems in standardization, and radio influence voltage values.

Two sessions sponsored by the Insulated Conductors Committee included papers on a variety of subjects, such as power cable shielding characteristics, a high-voltage capacitor-graded pothead, the Texada Island submarine cable crossing, and improving building-wire performance.

Science and Electronics

This technical division sponsored more than 40 papers comprising more than a dozen sessions on infrared devices, electronics, new electron tube developments, ceramic electron tubes and other devices, electrostatic processes, microwave tubes, thermionic energy converters, and modern circuit techniques.

The infrared devices session covered infrared detection systems, an image converter for thermal radiation; copper-doped germanium as a target material for an infrared camera tube; and a new photoconductive cell—the *7427*.

In the electronics field, ultrahigh-temperature (500 C) electronic transformers received special attention. A tentative proposed standard for low-power wide-band transformer and a tentative proposed standard for electronic power transformers aroused interest. Other papers were on the effects of transformer parameters on surge voltage transients in rectifier circuits, and on an analysis and synthesis (with the "complete" equivalent circuit) of the wide-band transformer. The use of alumina power as a potting material for electronic power transformers concluded the session.

The ceramic electron tube developments session was devoted to a new, rugged ceramic pencil tube for class *C* service, a ceramic tube for low-level amplifier use, and a ceramic hot-cathode gas rectifier for use in high-temperature applications. Other developments dealt with the rare earth hydride reservoirs and design considerations for modulators and converters using a new miniature beam-deflection tube.

Papers on various aspects of corona phenomena took up the major part of the session on electrostatic processes. There

were also papers on electrostatic propulsion for space vehicles and turbulent gas flow and electrical precipitation.

The session on microwave tubes devoted two papers to the traveling-wave tube which discussed the suppression and limiting of undesired signals in traveling-wave tubes and an *X*-band periodic-focused traveling-wave tube limiter chain. Another paper dealt with experiments on a series of *S*-band Crestatrons. In addition, there was a paper on a 1,000- to 2,000-mc voltage-tunable magnetron and a paper entitled "A Dual-Mode Pre-TR Tube." In the field of thermionic energy converters, there were papers on the high-vacuum and solid-state types and on the construction of a converter. Other subjects covered were the Los Alamos plasma thermocouple and the development of nuclear-powered thermionic-converter power systems.

Aspects and applications of the tunnel diode circuit, ferroelectric energy converter circuits, and solid-state switching circuits and amplifiers for airborne and space-vehicle control systems highlighted the two sessions on modern circuit techniques. Characteristics of wide-band direct couple amplifiers and a transistor Morse-to-teleprinter code converter were also discussed.

The Insulation Committee sponsored two sessions devoted, respectively, to solid and liquid dielectrics. Some of the topics covered in the session on solid dielectrics were an insulation system for Naval shipboard motors that are intermittently submersed, a new technique improving electrical and physical properties of inorganic insulation, and the determination of the toxicity of gases. The session on liquid dielectrics heard a discussion on the bubble theory for electric breakdown of liquid dielectrics and a report on the 1959 international symposium on conduction and breakdown in liquid dielectrics. A paper on the electrical stability of insulating oils was also presented.

Thermal life of varnished glass cloth and a study of thermal deterioration of enameled wire highlighted a session on thermal endurance. Also included were a paper on factors affecting the aging characteristics of various wire coating materials in transformer oil and one on a study of normality of distribution of thermal life-test data. The session on corona effects, also sponsored by the Electrical Insulation Committee, heard papers on the measurement and influence of surface charges on the inception voltage between dielectric and metal dielectric surfaces, on a capacitance bridge method for measuring integrated corona charge transfer and power loss per cycle, and on the study of discharges in dielectric voids by photomultiplier methods. Other subjects were the ionization and electron attachment coefficients in aklyl, and the electrical tracking resistance of polymers.

The Computing Devices Committee sponsored three sessions on control computers under the following general headings: application analysis for control computer selection, comparison of incremental (DDA) and whole-number (GPC) arithmetic computers, and special computer applications. In another session sponsored by the same committee, there were presentations on the automation of computer panel wiring and an automatic program checkout, among a group of other papers under the heading of "Approaches to the Solution of Computer Problems." In two additional sessions sponsored by the same committee, six papers were devoted to the design theory of combinational switching circuits which included the subjects of the minimization theory, representation of switching functions, and an introduction to switching (Boolean) algebra. The final session, covering computer application in manufacturing, was devoted to papers on integrated systems planning, production line balancing, and on an experiment in simulation of factory operation on a digital computer. Also presented was a paper on complete manufacturing information produced by computer for large a-c motor coils.

Will Gainfort Photo

AN INSPECTION TRIP to the Okonite Company's North Brunswick, N. J., cable plant was attended by 120 AIEE members. One of the points of interest was the modern plastics extruder here examined by: (*left to right*) L. S. Milligan, DeLong Corporation; G. M. Jeffares, Plantation Pipe Line Company; I. W. Borda, Okonite's vice-president and general sales manager; W. T. Robison, Plantation Pipe Line Company; Peter Zarakas, Consolidated Edison Company; and W. H. Underwood, Long Island Lighting Company. Mr. Milligan, Mr. Zarakas, and Mr. Underwood are members of the AIEE Committee that handled all inspection trips during the Winter Meeting.

Magnetic amplifiers and solid-state devices received strong attention at two sessions. Topics included solid-state firing circuits for trinistors, controlled rectifier frequency multipliers using inverter principles, and recent developments on magnetic-coupled multivibrators. The second session was devoted exclusively to magnetic amplifiers in such applications as symmetrical frequency multiplier circuits, and instabilities of push-pull magnetic amplifiers feeding the field of an electric machine.

Basic sciences were well represented with 16 papers presented at three sessions sponsored by the Basic Sciences Committee. Subject matter ranged from such topics as the measurement of temperature in welding arcs, and the electromagnetic induction damping of vibratory motion through the subject of the generalized recurrence relations in the analysis of nonlinear systems to the more rarefied discussion of conformal transformations in analog simulations of non-Laplacian fields. Included in the same session with this last subject were papers on difference equations and their applications, generalized Brillouin flow, and on the synthesis of linear filters with real or imaginary transfer functions. One entire session was devoted to electromagnets and related phenomena.

The session on nucleonics heard presentations on the safety aspects of a pressurized water nuclear reactor power plant and on the design of an eddy-current brake for a sodium-cooled nuclear power reactor. Other topics were the critical assembly work for the Enrico Fermi reactor and the principles of the power supply of the 12.5-Bev proton synchrotron at the Argonne National Laboratory.

The growing field of molecular electronics received the attention of 10 papers in two sessions sponsored by the Solid State Devices Committee. Presentations were made on molecular electronic phenomena, the theory and applications of a monolithic null device, and a microminiature full adder. Some new examples of molecular engineering were presented.

A symposium on radiation effects, sponsored by the Electrical Insulation and Nucleonics Committee, drew a highly interested audience to hear discussions on calculating the absorbed dose from electron irradiation, dosimetry, radiation effects and electronic components, thermoelectric

power, and transmission of electromagnet waves through an ionized atmosphere.

A silicon-controlled rectifier and 100-kw trinistors were topics highlighting the first of two sessions on semiconductor rectifying devices and applications sponsored by the Semiconductor Metallic Rectifiers Committee. The second session heard presentations on problems encountered in applying the silicon-controlled rectifier to control tungsten lamp loads, trinistor triode power inversion, and power semiconductor ratings under transient and intermittent loads.

The panel discussion on "New Challenges to Electrical Engineers from Medical and Biological Problems" drew a large and appreciative audience. The fields of physiology, radiology, biology, and space medicine were represented by scientists who offered engineers a group of stimulating problems awaiting solution. The AIEE had received a $450 grant from the National Science Foundation to support the organization of this special interdisciplinary panel discussion.

The closely related session on electrical techniques in medicine and biology demonstrated how engineers were meeting the challenge of the animate sciences. Some of the topics covered were: thermoelectrical applications in biomedical studies; experiments with air ions in the trachea; instrumentation for the diagnosis of coronary-artery disease; and new developments in heart-lung bypass systems. There was also a paper on the use of a low-power nuclear reactor in biology and medicine.

The subject of thermoelectricity was covered at a session sponsored by the Solid State Devices and Basic Sciences Committees. Papers on thermoelectric concepts for engineers, transient response and ripple effects in thermoelectric cooling cells, and a synthesis of the thermoelectric generators were presented.

Section Representatives Meet during AIEE Winter General Meeting

TOTAL attendance was 107 at the AIEE Section Representatives Meeting held Tuesday, February 2, during the Winter General Meeting of the Institute.

The meeting was called to order by W. E. Scholz, chairman of the Sections Committee, who introduced the secretary, G. B. Schleicher.

The first speaker to address the meeting was R. K. Fairley, chairman of the Membership Committee.

Mr. Fairley reminded the Representatives of the necessity of a 10% increase per year in Institute membership and pointed out the local aspects of the problem. He mentioned some worthwhile activities which have been undertaken by the Sections to encourage membership, such as sponsorship of study groups, courses, and technical group discussions to interest engineers, and formation of Subsections to overcome problems of geography.

G. R. Wilhelm, chairman of the Transfers Committee, discussed various matters relating to transfers.

From the standpoint of quantity of transfers, specific data on changes in member grades were presented. After analyzing transfers results to show the number of transfers per Section per 100 members in the Section, it was noted that the largest numbers of transfers per 100 members are in the smaller Sections.

During the discussion which followed the speakers' presentations, W. G. Vieth, chairman of the New York Section, reported on a meeting of representatives of the New York District, Section, and Membership Committee, who met to discuss what might be done to make membership in AIEE more attractive to students and young engineers. During this meeting, suggestions were made concerning the reorganization of Institute publications which form the basic contact with students.

The Section representatives also offered opinions on the necessity and value of rebates to Sections of entrance and transfer fees. They discussed the questions of whether or not the practice is really an incentive to membership, and who has greater need of the fees—National Headquarters or the individual Sections.

In summary, Chairman Scholtz stated that many Sections would like to see the rebates continued.

Unity of the Profession

T. M. Linville spoke on the subject of organizing the engineering profession to achieve unity.

After reviewing the Functional Plan (*Electrical Engineering*, February 1958, pp. 119-21), the speaker urged each Section and Subsection to send a report of opinion on the organization of the profession to the Secretary of the Institute.

Mr. Linville also mentioned a manual on the subject of unity prepared by the Intersociety Relations Committee which has been sent to the Sections to aid them in formulating their views.

The afternoon session began with a discussion by C. F. Savage, chairman of the Public Relations Committee.

He was followed by R. T. Ferris who reviewed the objectives of Institute public relations and pointed out the importance of having a public relations committee in the individual Sections.

The next speaker, R. C. Mayer, concentrated on two points: (1) the exhibit displayed during the Winter General Meeting which shows how AIEE reaches its public and lists publications and information aids, and (2) the press room set up for the Winter meeting which might offer suggestions to those wishing to organized a similar press room for Section meetings.

Mr. Savage concluded the public relations discussion by asking the Sections to help bring attention to the AIEE Special Technical Conferences and the work they accomplish.

R. R. Krezdorn, vice-chairman of the Student Branches Committee, stated that Sections must aid in the program of keeping graduating student members as members of the Institute.

According to the present system, the

Ross Photo

A CHECK for $2,500 was presented by B. H. Zacherle (right) to H. H. Sheppard (center), vice-chairman of the Member Gifts Campaign of the United Engineering Center. Mr. Zacherle is chairman of the Philadelphia Section Member Gifts Campaign, and the check represented the Philadelphia Section's contribution to the United Engineering Center Building Fund. Looking on is W. E. Scholz (left), chairman of the AIEE Sections Committee. Presentation of the check was made at the Section Representatives Meeting, February 2, during the AIEE Winter Meeting.

Student Branch notifies the Section of a graduate who has moved into the Section area. When the Section receives notice, an effort must be made to approach the young engineer and to interest him in meetings and other activities of the AIEE.

Mr. Krezdorn also spoke of the need for offering students stimulating programs in order to keep them interested in Institute affairs.

Member Gifts Campaign

H. H. Sheppard, vice-chairman of the AIEE Member Gifts Committee, introduced C. E. Davies, executive director of the United Engineering Center project.

Col. Davies presented a report on the progress of the Center, which is scheduled for completion during the Spring of 1961.

Mr. Sheppard emphasized the all-out effort needed to achieve AIEE's quota of $900,000, of which 90% has been contributed or pledged by approximately 40% of the Institute members.

Following Mr. Sheppard's appeal, a representative of the Philadelphia Section presented a check for $2,500 from Section funds as a contribution to the Center.

Mr. Scholz announced the following changes in AIEE Sections and Subsections, bringing the total number of Sections in the Institute to 114:

1. The Southern Arizona Section was formed, and assigned the three Arizona Counties of Cochise, Pima, and Santa Cruz. The effective organization date was August 1, 1959.

2. The Middle Tennessee Section, which was formerly the Tullahoma Subsection of the East Tennessee Section, was granted full Section status on December 1, 1959. The eight Tennessee Counties of Bedford, Coffee, Franklin, Grundy, Lincoln, Marshall, Moore, and Warren have been assigned to this new Section.

3. The new Bloomington Subsection of the Central Indiana Section was formed effective October 1, 1959. The five Indiana Counties of Brown, Greene, Martin, Monroe, and Owen have been assigned to this Subsection.

With the formation of the Bloomington Subsection and the transfer to full Section status of the Tullahoma Subsection, the total number of Subsections in the Institute remains at 77.

Effective August 1, 1959, the Upper Monongahela Valley Subsection of the Pittsburgh Section changed its name to "Upper Monongahela."

Among the matters on the day's agenda discussed by the Representatives was the problem of encouraging student interest in AIEE. As a partial solution, M. J. Smith offered the following resolution which was adopted by the group:

WHEREAS there is reason to believe that AIEE Section programs for students have failed to convey to the students a true impression of breadth, scope, and range of interest of the activities of the Institute Student Branches, and

WHEREAS the AIEE has a strong and enduring interest in maintaining the growth and vigor of its Student Branches,

IT IS HERE RESOLVED that the members of this meeting pledge themselves to exert all possible effort to induce program committee chairmen of Sections in proximity to student groups to provide a joint Section-student program on a subject which must be of such recent development and timely content as to certainly excite the interest of the most scientifically inclined electrical engineering student.

A number of Representatives described individual experiences in the area of Section-student relations.

Some other questions discussed by the Representatives were concerned with maintaining a Section roster and the use of IBM cards for Section records.

Board of Directors Proposes Extensive Constitutional Amendments

ON February 5, 1960, the last day of the Winter General Meeting at the Statler Hilton Hotel in New York, N. Y., the customary Board of Directors meeting was held. Present were 33 of the 35 Board members. A full agenda kept the Board busy from 9:00 a.m. until after 5:00 p.m. Some of the actions of general interest, as recorded by N. S. Hibshman, AIEE executive secretary, are briefly outlined here.

The treasurer reported a cash balance of $141,832 and total assets of more than $2 million. Advance commitments for next year's budget were approved in the form of an extension of the rebate of entrance and transfer fees to the Sections in 1960-61 and the underwriting of a student publication.

The feature of the meeting was the approval of a program presented by the Planning and Co-ordination Committee and the Special Task Force on Institute Activities and Organization. The Board voted to propose to the membership extensive Constitutional amendments designed to enlarge the Board and the Executive Committee to represent the diversified and expanding interests of the members.

Detailed explanations of the proposed amendments will be distributed to the membership with a ballot on or before April 1. Briefly, the purpose and extent of the proposed amendments are as follows:

To provide that all member interests are adequately represented on the Board of Directors, it is proposed to increase the number of voting members from the present 30 to 37. A maximum of 40 could be reached during a 4-year transition period. An enlarged and similarly distributed Executive Committee will, if approved, relieve the Board of administrative decisions. The proposed arrangement is expected to free the Board for policy legislative functions on which it can bring to bear the best informed and most representative thinking available.

After 2 years of study, a Special Task Force on Institute Activities and Organization brought to the Board, through the Planning and Co-ordination Committee, five major recommendations. The objective in all cases is to broaden the opportunity for active membership participation. Most of these will be implemented without amendment to the Constitution. However, the make-up of the Board is something that only a vote of the membership can authorize.

Membership Representation

The proposed changes result in a Board where the following membership interests are specifically represented:

1. Geographical areas are represented by the District Vice-Presidents, chosen by the District Executive Committee and elected by the membership through the present nominating procedure. There is no change proposed here.

2. Technological interests and backgrounds in the membership will be represented by Technical Vice-Presidents; one proposed by each Technical Division, and nominated by the same procedure for the same term of office as the District Vice-Presidents.

3. Functional areas of the Institute's activities will be represented by the Department Directors originating by the same nominating procedure as the Vice-Presidents except that the Departments are responsible for making the primary choice. The term of this type of Director is also 2 years, and he becomes chairman of the Department.

4. General membership interests are still covered by Directors-at-Large serving 4-year terms for which they are nominated by the Institute Nominating Committee as at present. The number of these is to be reduced from 12 to 8.

No change is proposed in the status of present Board members or those elected in 1960. The procedure for nomination and election remains the same in all cases including the right of petition by any 25 members to put a nominee on the ballot. Essentially, the only change is to enlarge the voting Board and insure coverage of interests and representation of different backgrounds, by making specific groups responsible for originating candidates for the Institute Nominating Committee to put on the slate.

The Executive Committee under the proposed amendments will be enlarged from 7 to 11 to include the president, treasurer, four Department directors; and by presidential appointment, one past-president and four other Board members. The Bylaws are expected to specify the chairmen of the Finance and Planning and Co-ordination Committees.

The transition will take 4 years. Assuming that Districts, Divisions, and Departments remain the same as August 1, 1960; the Board will consist of 37 voting members plus the nonvoting executive secretary beginning August 1, 1964. If approved

by the members, the program will be started with the 1960-61 administrative year.

Other amendments offered on the same ballot broaden the basis of eligibility for membership in the Institute in recognition of the close relationship between the work of scientists and electrical engineers.

New Bylaws Submitted

The Constitution and Bylaws Committee submitted at this Board meeting a preliminary draft of a new set of Bylaws especially drafted to supplement the new Constitution as adopted by the membership in the Spring of 1959. These should be ready for adoption by the Board of Directors at the June 1960 meeting to become effective on August 1, 1960. Two new Bylaws were adopted at this February 1960 meeting. One provides for the expansion of the Recognition Awards Committee to a maximum membership of 24 and another provides for the establishment of a New Activities Committee in the Technical Operations Department. This New Activities Committee is charged with the responsibility of identifying significant new developments in the science and art of electrical engineering and initiating AIEE activities to foster their development.

The Board took occasion to compliment the Intersociety Relations Committee on the preparation and dissemination of the book entitled "Organizing the Engineering Profession To Achieve Unity," and decided that getting a clear response from the membership to the proposals in this book justified putting off the request for a report from the Sections until well-organized and announced meetings could be held in the first half of 1960-61.

The Board heard reports from its representatives to United Engineering Trustees relative to the progress of the United Engineering Center Building. Construction began on December 14. More than 92% of the quota of funds assigned to AIEE has been raised. More than 40% of the members of AIEE have contributed. Complete confidence was expressed in the ability of the other 60% of the members to raise the remaining 8% of the quota.

Twenty-three members were advanced to the grade of Fellow. Their pictures and brief biographies will be found in future issues of *Electrical Engineering*.

The Board was officially notified of the appointment of Dr. I. S. Coggeshall as manager of the Institute's Technical Operations Services, as reported in the February issue of *Electrical Engineering*, p. 159.

The date for the 1960 Annual Meeting of the Institute was set for June 20, 1960, as a part of the 1960 Summer General Meeting in Atlantic City, N. J. The Board will hold its next meeting on the same occasion on Friday, June 24, 1960. The Executive Committee will meet on April 21, 1960, in New York when the main item of business will be consideration of the Budget for the fiscal year beginning May 1, 1960.

The Board expressed its appreciation to the 1960 Winter General Meeting Committee for a highly successful meeting.

Formation of Technical Groups Discussed by Technical Committee Chairmen

PLANS for the formation of Institute technical groups were discussed at the 22nd Forum of Technical Committee Chairmen, held on the evening of February 3, 1960.

C. T. Hatcher, chairman of the Technical Operations Department (TOD), opened the forum and introduced the first speaker, AIEE President J. H. Foote.

Referring to suggestions made at the preceding forum, Mr. Foote stressed the need to recommend only the papers of permanent reference value for publication in *Transactions*. In this way, more funds could be made available for the publication of timely technical material of interest to young engineers such as that which is being delivered at the special technical conferences. As an illustration, the AIEE president mentioned a well-attended Machine Tool Conference, at which the young men considering a large milling machine were not interested in the power input but were interested in the electric controls—computer, magnetic tape, and transistors—which compensated for all variables and executed precision control.

In conclusion, Mr. Foote stated the necessity of realigning many of the committees, elevating some of the subcommittees to full committee status. He also said that TOD should take more interest in the special technical conferences rather than favoring the general meetings.

The functions and operations of the New Technical Activities Committee recently organized were described and illustrated by Dr. R. A. Ramey, committee chairman. Subjects which have been initiated are energy conversion and molecular electronics. It was stated that the committee does not intend to encroach upon the scopes of existing technical committees and subcommittees. It was explained by Mr. Hatcher that according to the Ad Hoc Committee report, the function of the New Technical Activities Committee is "to supplement and facilitate the work of the technical committees."

A paper on the subject of "Institute Technical Groups" was presented by Dr. W. R. Clark. From a background of long experience in Section activities, the speaker outlined the history of the effort to organize technical groups on an Institute-wide basis including the recommendations of the Ad Hoc Committee, which have been approved in principle by the Board of Directors. Curves showing the increase in rate of membership growth of several sister societies in comparison with the AIEE, as well as the decline in Section meeting attendance, were presented. The yearly variation of attendance at the different kinds of Institute meetings compared with variation in Institute membership was used as a criterion of interest. The curves showed a 40% reduction in interest in all Section-sponsored meetings, while interest in the technical group meetings of the Sections as well as the general meetings remained practically constant, and interest in the special technical conferences had grown almost ten-fold in the past 10 years. It was concluded, therefore, that it seemed logical to combine this activity sponsored by the technical committees with the Sections' technical groups and to form Institute technical groups. The functions, duties, organization, and plans for publications and financing of these groups were outlined by the speaker.

Several discussions of the plan which

Pacific General Meeting Committee

Paul Osley Photo

PLANNING for the 1960 Pacific General Meeting is now under way. The General Committee and chairmen for the meeting, which will be held August 8-12 in San Diego, Calif., are: (*standing, left to right*) H. R. Hughes, publicity; R. T. Strong, treasurer; L. R. Knerr, hotel and registration; E. F. Kotnik, technical operations; Alvord Paull, finance; and Robert Kinslow, golf; (*seated, left to right*) G. B. Kenline, arrangements; W. A. Davis, transportation and inspection trips; G. C. Eggen, secretary; J. F. Sinnott, general chairman; and R. Marston, vice-chairman.

ensued pointed out that Section technical groups which are now a going activity did not follow the lines of the national technical organization, and concern was expressed about retaining Section autonomy over these technical groups. Dr. Clark explained that there was nothing compulsory about the plan, and a local group did not have to become a part of Institute technical groups. Most questions were answered by Dr. W. R. Clark, Dr. W. A. Lewis, and Mr. Hatcher.

Articles explaining to the membership the plan for the organization of Institute technical groups will be published in subsequent issues of *Electrical Engineering*.

Outstanding Young Engineers of 1959 Are Honored by Eta Kappa Nu

SEVERAL hundred members and guests of Eta Kappa Nu paid tribute to the outstanding young electrical engineer of 1959 and to three recipients of Honorable Mention awards at a dinner held February 1, 1960. Albrecht Naeter, society president, presided over the ceremonies and introduced past officers as well as previous winners of the Award and Honorable Mention.

The Award to the Outstanding Young Electrical Engineer of 1959 was presented to Dr. E. A. Sack, Jr., of the Research Laboratories of the Westinghouse Electric Corporation. The Award carried the citation: "By virtue of his honorable contributions to solid-state device research and development, particularly in the field of electro-luminescence, and his exceptional leadership in the civic and social life of his community." Dr. Sack was introduced by Dr. S. Herwald, engineering manager of the Westinghouse Electric Corporation.

Honorable Mention was awarded to W. O. Fleckenstein of the Bell Telephone Laboratories, Inc., with the following citation: "By virtue of his outstanding record in the field of communications training and development, and his unusually meritorious activities for church and community." The background of the recipient was outlined by G. W. Gilman of the Bell Telephone Laboratories, Inc.

Honorable Mention was awarded to K. H. Olsen with the citation: "By virtue of his exceptional contributions to advanced digital computer design and production, and his activities in behalf of the church." The background information concerning Mr. Olsen was given by Prof. J. W. Forrester, of the Massachusetts Institute of Technology.

Honorable Mention was awarded to J. W. Wentworth with the following citation: "By virtue of his many contributions to the development of color television, and his exceptional leadership in church and community activities." Background information was given by J. H. Roe of the Radio Corporation of America.

The principal address at the banquet was given by Dr. Ernst Weber, president of the Polytechnic Institute of Brooklyn, and chairman of the Jury of Award. The young men honored were challenged to even greater achievement and the speaker reminded the winners that: "Not only in science but in all areas of human endeavor there are a thousand and one opportunities for one to realize, to seize, and to become the acknowledged leader . . . Leadership requires then not only preparation for the unexpected but also wisdom to realize the timeliness. This holds not only for the sciences but also for moral, political, and economic issues."

Selection of this year's Outstanding Young Electrical Engineer and Honorable Mention recipients was made by a Jury of Award consisting of the following engineering leaders: Chairman—Ernst Weber, past president, Institute of Radio Engineers, (1959); J. B. Browder, president, Illuminating Engineering Society; Larry Dwon, past-president, Eta Kappa Nu; L. C. Holmes, director of research, Stromberg-Carlson Company, and vice-president,

NAMED outstanding young electrical engineer of 1959 by Eta Kappa Nu, Dr. E. A. Sack, Jr. (*center*), was congratulated by Albrecht Naeter (*left*), society president, and Dr. Ernst Weber (*right*), president of Brooklyn Polytechnic Institute.

CONGRATULATIONS for honorable mention as outstanding young electrical engineers of 1959 were extended to W. O. Fleckenstein (*left*) of Bell Telephone Laboratories and J. W. Wentworth (*right*) of Radio Corporation of America from W. B. Groth (*center*), chairman of the Eta Kappa Nu Recognition Award Committee.

AIEE; A. G. Kandoian, vice-president, International Telephone and Telegraph Laboratories, Inc.; A. Naeter, president, Eta Kappa Nu; and C. V. Roseberry, vice-president, Westinghouse Electric Corporation.

Eligible for the award is any man who on May 1 of each year has been graduated not more than 10 years from a regular course in electrical engineering from an American college or university and who is not more than 35 years of age. Eta Kappa Nu, the sponsor for the annual award, is the national electrical engineering honor society founded at the University of Illinois in 1904. The organization has more than 28,000 members, 71 college, and 12 alumni chapters in the United States.

Joint District Meeting Scheduled for April 12-14 in Charleston, W. Va.

CHARLESTON, W. Va., will be host to a joint meeting of the East Central District 11 and the new Allegheny-Ohio Valley District 14 on April 12-14, 1960, with headquarters in the Daniel Boone Hotel. The theme of the meeting is "Industrial Wonderland—Coal, Chemicals, and Power."

On Monday, April 11, at 8:00 p.m. a Welcoming Reception will be held at the Daniel Boone Hotel.

At 8:30 a.m. on Tuesday, an "Early Bird" Coffee Hour for all early risers will be held.

The general session will be called to order at 10:00 a.m. on Tuesday by C. B. Talley, honorary chairman of the Joint District Meeting. J. A. Shanklin, mayor of Charleston, will welcome the visitors to the city. C. H. Underwood, governor of West Virginia, will give an address welcoming visitors to the State of West Virginia. The principal speaker will be R. E. Salvati, president of the Island Creek Coal Company, who will discuss the future of coal in power generation, steel production, and the chemical industry.

A luncheon will be held following the general session. Ladies are invited.

The registration desk will be on the mezzanine in the Daniel Boone Hotel. It will be open from 5:00 p.m. to 9:00 p.m., Monday, April 11, and daily thereafter from 8:00 a.m. to 5:00 p.m.

Advance registration cards should be mailed to Gordon Hood, Allis-Chalmers Manufacturing Company, 506 Peoples Building, Charleston, W. Va. The use of these cards will avoid considerable delay at the registration desk. Members will pay registration fees upon arrival when they pick up identification badges, programs, etc. The registration fees payable at the meeting will be $4 for members and $7 for nonmembers.

The facilities of the Daniel Boone Hotel have been reserved for the AIEE members attending this meeting. Hotel room reservations should be made as far in advance as possible. In the event of an overflow, the Daniel Boone Hotel will arrange reservations at a nearby hotel. Reservations will be confirmed by the hotel. If assistance is needed, contact the Hotel Committee chairman, John Dennie, P. O. Box 965, Charleston, W. Va.

Rates for rooms are as follows:

Single Room with Detached Bath	$4.00–$4.50
Single Room with Bath	$5.00–$10.00
Double Room with Double Bed	$9.50–$15.00
Double Room with Twin Beds	$10.50–$15.00
Two Room Suite	$21.50–$22.50
Three Room Suite	$35.00

A social hour and banquet for all members, wives, and guests will be held at 6:00 p.m. on Wednesday, April 13. Dr. P. H. Miller, Jr., chairman, Experimental Physics Group, General Atomic Division of the General Dynamics Corporation, will speak on "From the Atom to Your Home —Electric Power Generation without Moving Parts."

At 6:00 p.m. on Tuesday, April 12, an informal party for members and wives will be held. An excellent dinner will be served, followed by a program of sufficient variety to satisfy even the most discerning.

The following events should provide entertainment for ladies accompanying their husbands to the meeting.

On Tuesday afternoon, a trip to the State Capitol and Governor's Mansion has been arranged.

On Wednesday morning, a trip to the Bienko Glass Company is planned. This will be followed by a luncheon.

On Thursday morning there will be an interior decorating show and luncheon at Woodrum's Tea Room.

West Virginia Institute of Technology will sponsor a student prize paper competition on Wednesday morning. Cash awards will be made to the first, second, and third place winners.

Wednesday afternoon, there will be a conducted tour of the Union Carbide Technical Center at South Charleston.

Inspection Trips

A program of inspection trips of both technical and general interest has been arranged for those attending the meeting. Tickets and information regarding inspection trips may be obtained at the registration desk. The following is a list of these events.

Union Carbide Technical Center—South Charleston, W Va. (Tuesday afternoon. April 12).

Kaiser Aluminum & Chemical Corporation—Ravenswood, W. Va. (Wednesday morning, April 13).

Kanawha Power Plant—Glasgow, W. Va. (Wednesday morning, April 13).

Coal Preparation Plant, Cannelton Coal & Coke Company, Cannelton, W. Va. (Wednesday afternoon, April 13).

Owens-Illinois Glass Company, Charleston, W. Va. (Thursday morning, April 14).

Members of the Joint East Central and Allegheny-Ohio Valley District Meeting Committee are: C. M. Hunt, general chairman; C. B. Talley, honorary chairman; L. M. Roth, chairman-at-large; J. H. Miller, secretary; M. W. Illing, treasurer; R. H. Hively, advisory; W. C. McMahan, administration; B. W. Whittington, finance; J. C. Norton, technical program; J. R. McGinnis, student meeting; P. W. Sinsel, special meetings; H. L. Austin, entertainment; G. W. Unangst, arrangements; and Z. C. White, publicity.

NAMED one of the most efficient steam power plants in the world, the Kanawha River Plant of the Appalachian Power Company is located about 20 miles southeast of Charleston. The plant uses more than a million tons of coal a year to generate electricity. An inspection trip to this plant will be made during the Joint District Meeting.

Technical Program

The tentative technical program follows:

Tuesday, April 12

9:00 a.m. Mining Industry Committee—Daniel Boone Parlor "C"

Chairman: J. A. Buss, Reliance Electric & Engineering Co.

The Mining Industry Committee will meet to discuss participation in future AIEE meetings.

10:00 a.m. General Session—Shrine Mosque Auditorium

Chairman: C. B. Talley, Appalachian Power Co.

2:00 p.m. Mining Industry—Daniel Boone Main Ballroom

Chairman: J. A. Erskine, Eastern Gas & Fuel Associates

DP.* A review of Mine Grounding Practices. *D. E. Hamilton*, General Electric Co.

DP.* Portable Silicon Rectifiers. *R. G. Clark*, Westinghouse Electric Corp.

DP.* Motors for Continuous Miners. *J. A. Buss*, Reliance Electric & Engineering Co.

DP.* Fuel Cells. *T. G. Kirkland*, Allis-Chalmers Manufacturing Co.

2:00 p.m. Cathodic Protection and Grounding—Daniel Boone Parlors "A" and "B"

Chairman: R. G. Medley, Union Carbide Olefins Co.

DP.* Demonstrating Electrochemical Corrosion Reactions by the Use of Transparent Cells in an Optical Projector. *G. E. Cox*, consulting engineer

60-4. The effect of Electrical Grounding Systems on Underground Corrosion and Cathodic Protection. *B. Husock*, Harco Corp.

55-113. Underground Corrosion on Rural Electric Distribution Lines. *O. W. Zastrow*, Rural Electrification Administration

2:00 p.m. Fire Prevention in Industry—Daniel Boone Parlor "C"

Chairman: J. J. Duggan, Union Carbide Chemicals Co.

DP.* How the National Electric Code, Underwriters Laboratory, and the National Fire Protection Association Served Industry. *M. Brandon*, Underwriters Laboratories

DP.* Static and Induced Current Grounding. *A. D. Colburn*, Union Carbide Chemicals Co.

DP.* Safe Instrumentation in a Chemical Plant. *L. J. Rogers*, Union Carbide Olefins Co.

DP.* Some Rating Bureau Problems with Electrical Installations. *D. G. Greenfield*, West Virginia Rating Bureau.

Wednesday, April 13

9:00 a.m. Chemical Industry—Instrumentation & Data Transmission—Daniel Boone Clubroom.

Chairman: G. P. Jones, C & P Telephone Co.

DP.* Analytical Instruments for Process Control. *M. D. Weiss*, Union Carbide Chemicals Co.

DP.* Data-Transmission Capabilities of the Telephone Network. *H. R. Gravely*, C & P Telephone Co.

DP.* Data—Phone as a Linkage in Process Control Systems. *M. J. Zollner*, American Telephone & Telegraph Co.

9:00 a.m. Mining Industry—Daniel Boone Main Ballroom

Chairman: J. A. Erskine, Eastern Gas & Fuel Associates

DP.* Electric Equipment for Cleaning Plants. *C. H. Paris*, U. S. Steel Co.

*District papers will not be printed by the Institute; however, they may be available at the meeting at the discretion of the author.

REAR portions of the head of Kaiser Aluminum & Chemical Corporation's new plate stretcher at the Ravenswood, W. Va., Works. The gripping mechanism on the 30-million-pound machine is capable of handling aluminum plate up to 6 inches in width and 60 feet in length. Note the overhead crane lowering the plate into position.

Kaiser Aluminum Photo

DP.* Control of Fans and Substations by Carrier System. Femco Engineering Co.

DP.* Remote Control Highwall Mining. *J. W. Heimaster*, Union Carbon Olefins Co.

9:00 a.m. Student Prize Papers—Daniel Boone Parlor "C"

Chairman: J. R. McGinnis, Appalachian Power Co.

Six judges will determine the winning papers. Prizes will be awarded at the Wednesday evening banquet.

9:00 a.m. Fire Prevention in Industry—Daniel Boone Parlors "A" and "B"

Chairman: J. J. Duggan, Union Carbide Chemicals Co.

DP.* Booby-Traps. *H. H. Fawcett*, General Electric Co.

DP.* The New Electrical Code and Fire Safety. *F. Stetka*, National Fire Protection Association

DP.* Impressions of a Fire Protection Design Engineer. *J. J. Walker*, Union Carbide Chemicals Co.

2:00 p.m. Industrial Power—Daniel Boone Main Ballroom

Chairman: C. O. Steinmetz, Union Carbide Chemicals Co.

DP.* The Electrical Testing of Rubber and Plastic Insulated Power Cables. *W. A. Beasley*, Anaconda Wire & Cable Co.

60-138 Using the Digital Computer in Industrial Power System Design. *R. F. Cook, A. D. Patton*, Westinghouse Electric Corp.

DP.* Relay Protection for Large Motors. *J. F. Fesler, P. E. Drake*, Union Carbide Olefins & Chemicals Cos.

DP.* Static Protective Relays. *N. Kreekon*, Allis-Chalmers Manufacturing Co.

2:00 p.m. Chemical Industry—Computation and Control—Daniel Boone Clubroom

Chairman: G. P. Jones, C & P Telephone Co.

DP.* Analog Computer Models for Process Control. *W. B. Field*, Union Carbide Chemicals Co.

DP.* Digital Computer for Process Control. *K. R. Knoblauch*, Minneapolis-Honeywell Regulator Co.

DP.* The Role of the General Purpose Computer in Plant Maintenance. *F. H. Winterkamp*, E. I. duPont de Nemours & Co., Inc.

2:00 p.m. Cathodic Protection and Grounding—Daniel Boone Parlors "A" and "B"

Chairman: R. G. Medley, Union Carbide Olefins Co.

DP.* Demonstration of the Theory of Cathodic Protection. *W. J. Kretschmer*, Columbia Gas Service Corp.

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AIEE Order Department
33 West 39th Street.
New York 18, N. Y.

DP.* Grounding and Bonding. *A. S. Brookes*, Public Service Electric and Gas Co.

DP.* Power System and Equipment Grounding in Conformance with Cathodic Protection Practices. *K. R. Gosnell, R. G. Medley*, Union Carbide Chemicals and Olefins Cos.

2:00 p.m. Engineering Education—Daniel Boone Parlor "C"

Chairman: E. E. Dreese, Ohio State University

DP60-594. A Program in Engineering Science for All Engineering Students. *A. T. Murphy*, University of Wichita

DP.* Evolution of Electronic Components. *J. C. Michalowicz*, Catholic University of America

DP.* An Experiment in Laboratory Education. *Gordon Kent, W. H. Card*, Syracuse University

Thursday, April 14

9:00 a.m. Industrial Power—Daniel Boone Main Ballroom

Chairman: C. O. Steinmetz, Union Carbide Chemicals Co.

DP.* Unusual Features of the Kanawha Generating Plant. *F. M. Porter*, Appalachian Power Co.

DP.* Selecting an X-Ray Gauge for Measuring the Thickness of Aluminum Foil. *R. W. Wall*, Kaiser Aluminum & Chemical Corp.

DP.* The Plasmarc Torch. *O. H. Nester*, Linde Co.

9:00 a.m. Engineering Education—Daniel Boone Parlor "C"

Chairman: E. E. Dreese, Ohio State University

DP.* A Communications Engineering Course for a Fast Moving Technology. *C. T. Koerner*, American Telephone & Telegraph Co.

DP.* Better Engineering through Better Communications. *W. M. Terry, Jr.*, Allis-Chalmers Manufacturing Co.

2:00 p.m. Space Problems Symposium—Shrine Mosque Auditorium

Chairman: J. L. Simpson, Union Carbide Chemicals Co.

DP.* Radio Astronomy. *F. D. Drake*, National Radio Astronomy Observatory

DP.* Space Instrumentation and Guidance. *Roy Crask*, Minneapolis-Honeywell Regulator Co.

DP.* Application of Nuclear Power to Space Problems. *Sidney Krasik*, Westinghouse Electric Corp.

DP.* Space Motors and Propellants. *Mark Ghai*, General Electric Co.

Mailed Announcement

A mailed announcement of this meeting will be sent to members in District 11 and 14. If a copy is desired by members in othe Districts, this may be obtained from E. C. Day, assistant secretary for technical papers and programs, TOD, American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N. Y.

Great Lakes District Meeting To Feature 72 Technical Papers, 8 Trips

THE AIEE Great Lakes District meeting will be held at the Pfister Hotel on April 27–29, 1960, and will feature 72 technical papers presented by outstanding speakers. Eight interesting inspection trips, closely co-ordinated with the technical papers, will be available.

An active ladies' program and relaxing social events will also be offered.

The general session will be held in the Fern Room of the Pfister Hotel on Wednesday at noon, April 27. J. H. Foote, president of the AIEE, will speak at this session. He will be introduced by R. B. Gear, vice-president of the Great Lakes District.

On Thursday noon, April 28, in the Fern Room, an informal luncheon will be held. The speaker will be G. B. Elliott, sales manager of the Schultz Box Company, Milwaukee. His talk on "sales magic" will divulge the many secrets that make selling the interesting profession that it is. Luncheon tickets are $4.

The program has been carefully planned around the theme "Controls—Pearl Street to Cape Canaveral." Specialized fields that will be covered include transmission and distribution, industrial controls, data processing, rotating machinery, feedback control, missiles and guidance, education, and machine tool control. Inspection trips will be co-ordinated with the technical papers to provide maximum value to the members attending.

On Thursday, April 28, the Great Lakes District Student Paper Competition will be held covering students from the 17 Student Branches. The first place winner will receive a $25 award and have the distinction of representing the District at the Summer General Meeting in Atlantic City, N. J. The second place winner will receive a $25 award, and the third place, a $15 award.

Additional trophies and cash awards will also be made from various Section contributions.

Registration

Registration facilities will be located on the seventh floor lobby of the Pfister Hotel.

For those arriving on April 26, the registration desk will be open from 5:00 to 9:00 p.m. During the meeting, registration hours will be from 8:30 a.m. to 5:00 p.m., except on the final day, Friday, April 29, when the registration desk will close at 12:00 noon.

Registration fees are as follows: Members—$4, nonmembers—$7, student members—no fee, and wives of registrants—$2. Advance registration cards should be returned at an early date with an indication of the activities each one plans to attend. This will give the committees an opportunity to make adequate provisions for all affairs. Money should not be sent with registration. It is recommended that immediately upon completing registration at the hotel, each one procure tickets for inspection trips, luncheons, the buffet dinner, the theater party, the banquet, and ladies activities.

A block of rooms has been set aside at the Pfister Hotel, 424 E. Wisconsin Ave., to accommodate those planning to attend the meeting. The hotel registration card should be completed and returned promptly to the Pfister Hotel. The Pfister Hotel will arrange for any alternate rooms, should their facilities be completely sold out.

Rates per day are as follows:

Single Room (one person)	$6.00– $9.00
Double Room—double bed (two persons)	$8.50–$11.50
Double Room—twin beds (two persons)	$10.00–$16.00
Suites (two and three rooms) ..	$22.00–$50.00

A program for the wives of the men attending the Great Lakes District meeting has been planned by Mrs. E. A. Dickinson and the members of the Ladies' Committee.

Ladies' Coffee Hours have been planned for Wednesday, Thursday, and Friday at 9:30 a.m. in the Empire Room of the Pfister Hotel.

Wednesday morning at 10:30 a.m., a tour of the Junior House, leading designer and manufacturer of women's apparel, will be made at 1:30 p.m.

Wednesday, a tour of the WTMJ radio and WTMJ-TV studios will be made.

Thursday at noon, a special luncheon

LARGEST and most modern addition to the electric supply system of the Wisconsin Electric Power Company, the Oak Creek Plant (left) will be visited during the Great Lakes District Meeting.

Wisconsin Electric Power Company Photo

will be held at the University Club. This will be followed by a tour of the Milwaukee Art Center in the War Memorial Building on Milwaukee's lake front.

On Wednesday, April 27, at 5:30 p.m., a typical Milwaukee "Gemütlichkeit" party will start, with free beer followed by a $5 buffet dinner in the Fern Room. Then at 7:45 p.m., buses will take members to the Miller Theatre to see the musical "Brigadoon" which begins at 8:30 p.m. Tickets are priced at $3.

On Thursday evening, April 28, the grand banquet will be held in the Fern Room. Cocktails will be served at 6:00 p.m. The banquet will begin at 7.00 p.m. Tickets which include both are $7.50 each.

On Friday noon, April 29, a farewell luncheon will be given in the Fern Room. Luncheon tickets are $4.

Inspection trips will be made to the following places:

The Louis Allis Company, Milwaukee, Wis. (Wednesday, April 27, 2:00 p.m.)

Square D Company—Good Hope Plant, Glendale, Wis. (Thursday, April 28, 9:00 a.m.)

Cutler Hammer Inc.—Northside Plant, Milwaukee, Wis. (Thursday, April 28, 9:00 a.m.)

Allen-Bradley Company, Milwaukee, Wis. (Thursday, April 28, 9:00 a.m.)

A-C Spark Plug—Electronics Division of General Motors—Oak Creek Plant, Milwaukee, Wis. (Thursday, April 28, 2:00 p.m.)

Line Material Industries—New Thomas Edison Short Circuit Laboratory, Franksville, Wis. (Thursday, April 28, 2:00 p.m.)

Allis-Chalmers Manufacturing Company, West Allis, Milwaukee, Wis. (Friday, April 29, 9:00 a.m.)

Wisconsin Electric Power Company—Oak Creek Plant, Milwaukee, Wis., (Friday, April 28, at 9:00 a.m.)

The General Committee for the meeting comprises: J. A. Deubel, general chairman; R. J. Ungrodt, secretary and treasurer; H. C. Brem, administration and publicity; L. Matthias, technical program; H. Whiting, inspection trips; R. E. Horn, registration and hotels; E. A. Dickinson, entertainment; B. Wheeler, finance; Mrs. E. A. Dickinson, ladies' program; and W. McCoy, student activities.

Technical Sessions

The tentative technical program for the meeting follows:

Wednesday, April 27

9:30 a.m. Transmission and Distribution—Mirror Room

Presiding, W. A. Schulz, Public Service Company of Indiana

DP.* Large Metropolitan Bulk Power Substations. *C. N. Peters, E. Stevens,* Wisconsin Electric Power Co.

DP.* Computer Studies for System Planning and Operation of Electric Power Systems. *Charles Concordia, F. J. Maginniss,* General Electric Co.

DP.* Performance Characteristics of Static Overcurrent Relays. *F. Free, M. Sherfey,* Allis-Chalmers Manufacturing Co.

*District papers will not be printed by the Institute; however, they may be available at the meeting at the discretion of the author.

Torkel Korling Photo

THE GOOD HOPE PLANT of Square D Company was built primarily to mass produce high volume motor control components. This plant has been named one of the top ten industrial plants in the country for 1958 and is on the inspection tour program for the Great Lakes District Meeting.

DP.* Application of Secondary Unit Substations in Industrial Distribution Systems. *T. S. Banghart,* Pennsylvania Transformer Division, McGraw Edison Co.

9:30 a.m. Industrial Control—East Room North

Presiding: D. C. Walker, Square D Company

DP.* Shading Coil Magnet of New Design. *H. J. Kubiak,* University of Wisconsin; *L. H. Matthias,* Allen-Bradley Co.

DP.* Automation at General Merchandising Distribution Center. *E. W. Wilk, Miller & Waltz, Arthur Young,* Allen-Bradley Co.

DP.* Automatic Press Slide Positioner. *R. D. Meier, E. G. Anger,* Square D Co.

DP.* Logic System Design with NORS. *C. F. Meyer,* Square D Co.

9:30 a.m. Computors and Data Processing in Control Systems—East Room South

Presiding, T. B. Jochem, Cutler-Hammer, Inc.

DP.* Application of Digital Computers to Process Control Problems. *R. S. Gillett,* General Electric Co.

DP.* Remote Data Logging. *W. F. Cruess,* Westinghouse Electric Corp.

DP.* Data Phone. *C. H. Platt,* American Telephone and Telegraph Co.

DP.* A Precise Timer for Control of the Thermofusion Experiment at Princeton. *P. E. Slavin,* Radio Corporation of America

2:00 p.m. Transmission and Distribution—Mirror Room

Presiding, J. C. Foss, Commonwealth Edison Co.

DP.* VAR Generation and Control on a Compact Metropolitan System. *R. P. Huber,* Indianapolis Power and Light Co.

DP.* Dual-Cooling in Large Substation Transformers. *T. H. Progler,* Allis-Chalmers Manufacturing Co.

DP.* A Study of Ionization Detection and Measurement Methods. *C. J. Miller, Jr. J. F. Wittibschlager,* Ohio Brass Co.

DP.* EHV Transformers and Bushings. *S. Bennon,* Westinghouse Electric Corp.

2:00 p.m. Industrial Control—East Room North

Presiding, J. E. Jones, Cutler-Hammer, Inc.

DP.* Introduction to Electrostatically Influenced Force Transmitting Fluids. *A. J. Mason,* Warner Electric Brake and Clutch Co.

60-636. An Analysis of the Dynamics of an Electromechanical System. *Roy Hyink,* Cutler-Hammer, Inc.

DP.* Measurement of Process Pressures at Elevated Temperatures. *R. L. Eckman,* Barber-Coleman Co.

DP.* Studies of Electrodynamic Forces Occurring at Electrical Contacts. *A. C. Snowden,* Cutler-Hammer, Inc.

DP.* A-C Contractors Supplied by Long Control Lines. *R. P. Alley,* General Electric Co.

2:00 p.m. Electronic Instrumentation—East Room South

Presiding: Walter Richter, consulting engineer

DP.* The C Stellerator Central Control System. *C. W. Little, Jr.,* Allis-Chalmers Manufacturing Co.

DP.* A Swept Solar Spectrum Analyzer Covering the 2-4 Kmc Band. *Frank Haneman,* Airborne Instruments Laboratory

DP.* Detection and Control of Aircraft on the Airport Surface. *M. A. Warskow, J. E. Woodward,* Airborne Instruments Laboratory

DP.* Selective Signalling Decoder. *J. D. Malone,* General Motors Corp.

Thursday, April 28

9:00 a.m. Transmission and Distribution—Mirror Room

Presiding: N. A. Ricci, Wisconsin Electric Power Co.

DP.* Schemes for Switching and Protecting Pad-Mounted Transformers. *H. J. Barta,* S & C Electric Co.

DP.* Safety-Type Plug-In Busway. *N. Shackman, R. W. Thomas,* Bulldog Electric Products Co.

DP.* Modern Instrumentation in a Short-Circuit Research Laboratory. *E. F. Veverka, G. H. Manke,* Line Material Industries

DP.* Termination of Low-Voltage Power Cables. *G. E. Lusk,* G & W Specialty Co.

9:00 a.m. Rotating Machinery—Executive Suite

Presiding: L. I. Rosenberg, Allis-Chalmers Manufacturing Co.

DP.* Synchronizing and Damping Torque Coefficients of Synchronous Machines. *R. V. Shepherd,* General Electric Co.

DP.* Eddy-Current Losses in Stator Coil Gas Ducts for Conductor-Cooled Generators. *L. V. Van Laanen, S. A. Tomsic,* Allis-Chalmers Manufacturing Co.

DP.* Maintenance Aids for Steel Mill Rotating Equipment. *J. H. Greiner,* Allis Chalmers Manufacturing Co.

DP.* New Contactorless Precision D-C Hoist Has Wide Speed Range and Torque Control. *A. Hansen, J. H. Karlson, R. Mierendorf,* Louis Allis Co.

9:00 a.m. Feedback Control Systems—East Room South

Sponsored by Feedback Control Systems Committee

Presiding: T. J. Higgins, University of Wisconsin

DP.* A Variable Temperature Cabinet for Determining the Transfer Function of Room Thermostats. *C. C. Smith,* Johnson Service Co.

DP.* Control Aspects of a "Variable Inertia" System. *D. A. Lieberman,* Booz-Allen Applied Research, Inc.

DP.* Optimum Synthesis of Linear Discrete-Data Control Systems by the Modified Z-Transform Method. *J. T. Tou,* Purdue University

DP.* Some Aspects of A-C Control Systems Analysis. *C. A. Halijak,* Kansas State University; *T. J. Higgins,* University of Wisconsin

DP.* A Mathematical Study of Servometer Terminal Properties Using Linear Graph Theory. *R. C. Dubes,* Michigan State University

Thursday, April 28

2:00 p.m. Industrial Control—East Room North

Presiding: D. B. Fitzpatrick, Allen-Bradley Co.

DP.* The Work of the Engineer in Designing Packaged Adjustable-Speed Systems. *S. P. Finnegan,* General Electric Co.

DP.* Automatic Speed Regulation of D-C Motors Using Combined Armature Voltage and Motor Field Control. *Ansgar Hansen, A. W. Wilkerson,* Louis Allis Co.

DP.* Synchro-Positioned Conveyor System Controls Production Rate. *A. J. Pasion,* Square D Co.

DP.* An Adjustable-Speed Reversing Electronic Motor Controller. *John Callan, Joseph Moser,* Allen-Bradley Co.

DP.* Closed Loop Feedback Control for a 250-Inch Paper Supercalendar. *R. P. Veres,* Reliance Electric Engineering Co.

2:00 p.m. Rotating Machinery—Executive Suite

Presiding: C. S. McNeer, Wisconsin Electric Power Co.

DP.* Dynamic Equations of the Inductor Alternator for Analog Computer Representation in Voltage Regulator Studies. *C. H. Thomas,* University of Kansas

DP.* Brushless Exciter. *A. S. Wolanin,* Westinghouse Electric Corp.

DP.* A Method for Determining the Response of a System to Loss of Excitation. *J. M. Fleissner,* Wisconsin Electric Power Co.

DP.* Electrical Features of Oak Creek Power Plant Unit No. 5. *J. B. Prince, R. P. Spors,* Wisconsin Electric Power Co.

2.00 p.m. Feedback Control Systems—East Room South

Sponsored by Feedback Control Systems Committee

Presiding: L. F. Kazda, University of Michigan

DP.* Supervisory Control System Using a Sinusoidal Test Signal and a Model. *R. A. Hannen,* Ohio State University

DP.* Optimization of Linear Control Systems for Minimum Settling Time by the Second Method of Liapunov. *J. E. Gibson, Z. V. Rekasius,* Purdue University

DP.* Optimum Filters: Extensions and Generalizations of Wiener Theory—A Tutorial Account. *F. J. Beutler,* University of Michigan

DP.* Time-Lag Systems. *N. H. Choksy,* Johns Hopkins University

DP.* Dynamic Programming in Design of Feedback Control Systems. *K. J. Schlager,* General Motors Corp.; *T. J. Higgins,* University of Wisconsin

Friday, April 29

9:00 a.m. Missiles and Guidance—East Room South

Presiding: P. O. Larson, AC Spark Plug Division, General Motors Corp.

DP.* Space Vehicle Attitude Control System. *R. P. Petersen, J. W. Dunham, D. A. Libermann,* Booz-Allen Applied Research Inc.

DP.* Comparison of Surface-to-Air Missile Autopilot Loops. *Robert Schaaf, John Heisler,* Bendix Aviation Corp.

DP.* Control Loops in Inertial Guidance Systems for Ballistic Missiles. *John Sheldrick, George Hughes,* General Motors Corp.

DP.* Design Study of Attitude Control for Able Star Vehicle. *E. P. Blackburn,* Space Technology Laboratories

9:00 a.m. Education—Mirror Room

Presiding: Walther Richter, consulting engineer

DP.* Explosion in Engineering. *W. B. Swift,* University of Wisconsin

DP.* Education for 2000 A.D. *J. D. Horgan,* Marquette University

DP.* Curriculum Evolution in Electrical Engineering Education. *H. A. Peterson,* University of Wisconsin

DP.* The Engineering College and the Technical Institute of Tomorrow. *R. J. Ungrodt,* Milwaukee School of Engineering

9:00 Industrial Control—East Room North

Presiding: R. J. Weesner, Louis Allen Co.

Conference Papers Open for Discussion

Conference papers listed below have been accepted by AIEE *Transactions* and are now open for written discussion until April 29. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, AIEE, 33 W. 39th St., New York 18, N. Y., on or before April 29.

58-1391 **Accelerated Voltage Endurance Tests.** *R. G. Rhudy, H. E. Mazanek*

59-120 **Electronic Transformer Design by Digital Computers.** *L. F. Deise, Wade Etchison, Reuben Lee*

59-892 **The Texada Island Submarine Cable Crossing.** *P. J. Croft*

59-1076 **On the Transmission of Information by Orthogonal Time Functions.** *H. F. Harmuth*

59-1166 **Induced Currents in Supporting Steel for a 10,000-Ampere Generator Open Bus.** *G. K. Sebold*

59-1190 **A Magnetic Tape-to-Paper-Tape Converter.** *M. Ringer, L. Mintzer*

59-1201 **Ground Electrode Potential Gradients from Model Tests.** *H. R. Armstrong, L. J. Simpkin*

59-1295 **Pigmented Polyester Magnet Wire for High-Temperature Operation.** *F. A. Sattler, L. C. Scala*

59-1296 **Optimization of the Adaptive Function by Z-Transform Method.** *S. S. L. Chang*

60-40 **Threshold 60-Cycle Fibrillating Currents.** *C. F. Dalziel*

60-46 **A Test Set for Measurement of Envelope Delay Distortion at Audio Frequencies with 1-Microsecond Precision.** *W. A. Codd*

60-97 **A Capacitance Bridge Method for Measuring Integrated Corona Charge Transfer and Power Loss per Cycle.** *T. W. Dakin, P. J. Malinaric*

60-101 **Experiments with Air Ions of the Trachea.** *J. C. Beckett, A. P. Krueger*

60-120 **The Relative Merits of Incremental and Conventional Digital Computers in Air-Borne Real-Time Control.** *S. M. Shackell, J. G. Tryon*

60-183 **A Step-Driven Digital Magnetic Recorder.** *J. G. Hansen*

60-201 **An Analysis of a Polarized Electromagnetic Drive System and of Vibrator Systems.** *R. S. Nunn*

Preprints may be purchased at 50¢ each to members, $1.00 to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 W. 39th St., New York 18, N. Y.

DP.* Co-ordination of Adjustable-Speed Drive Characteristics with Load Requirements. *C. G. Helmick*, Westinghouse Electric Corp.

DP.* Computer Study of Co-ordinated Main and Edger Drives for a Reversing Rolling Mill. *P. J Wirtz, F. A Manners*, Square D Co.

DP.* Wide Range D-C Center Wind Drive. *Byron Jones, Thomas Pare*, Louis Allis Co.

DP.* Fast Response Static A-C Hoist Control. *C. B. Sanborn*, Square D Co.

2:00 p.m. Missiles and Guidance—East Room South

Presiding: J. H. Bell, AC Spark Plug Division, General Motors Corp.

DP.* Attitude Control for an Unmanned Interplanetary Vehicle. *E. J. Frey*, Massachusetts Institute of Technology

DP.* Velocity Vector Steering for Ballistic Missiles. *Glen Kleinhessilink*, General Motors Corp.

DP.* Terminal Guidance for Unmanned Interplanetary Vehicle. *W. J. Williams, R. Gates, J. Steinhilber*, Astrionics Laboratory, International Telephone and Telegraph Corp.

DP.* Control Systems for Ballistic Missiles: Requirements, Mechanism, and Problems. *Raymond Rath*, Air Force Ballistic Missile Division

2:00 p.m. Machine Tool—East Room North

Presiding: R. R. Schmitz, Giddings & Lewis Machine Tool Co.

DP.* Dual-Purpose Synchronizing and Dependent-Drive Time-Sharing for Point-to-Point Numerical Control. *G. W. Younkin*, Giddings & Lewis Machine Tool Co.

DP.* The Servo Controlled Positioning System for Machine Tools. *R. L. Filmore*, Minneapolis-Honeywell, Machine Controls Division

DP.* Numerical Positioning Controls in Retrospect. *Richard Sitts*, General Electric Co.

DP.* We Design with Maintenance in Mind. *M. C. Cridlebaugh*, W. F. & John Barnes

Northeast District 12 Meeting To Be Held May 2-4 in Providence, R. I.

THE Northeast District 12 meeting will be held May 2-4, 1960, at the Sheraton-Biltmore Hotel in Providence, R. I. "Electricity—Key to the Sixties" is the theme of the 3-day meeting which will include a complete technical program as well as a schedule of interesting inspection trips, social activities, and a ladies program.

On Sunday, May 1, from 3:00 p.m. to 6:00 p.m., a reception will be held in the State Suite, Room 1557, of the Sheraton-Biltmore, for members and wives as a general get-together and a welcome for early arrivals.

The luncheon, Monday, May 2, in the main ballroom of the hotel will formally welcome the members and guests with E. G. Twohey, president of the Narragansett Electric Company, Providence, as the main speaker.

Blocks of rooms have been set aside at the Sheraton-Biltmore Hotel for members and guests attending this meeting. Requests for reservations should be sent to the Sheraton-Biltmore Hotel, Providence 3, R. I., mentioning AIEE and giving date and approximate time of arrival and the date of departure. All reservations must be made by April 22, 1960.

The room rates are as follows:

Single Room	$6.85 to $12.50
Double Room	$10.85 to $13.85
Twin Bedrooms	$12.50 to $16.50
Rollaway Bed	$3.00 each

Advance registration cards received in the mail should be filled out and returned promptly. This will save time in completing registration details upon arrival at the hotel and will permit the committee to make necessary arrangements for all inspection trips.

The registration desk, located in the upper lobby, will be open on Sunday from 5:00 p.m. to 8:00 p.m., Monday and Tuesday from 8:30 a.m. to 5:00 p.m., and on Wednesday from 8:30 a.m. to 12:00 noon. Registration fees are $4 for members, $7 for nonmembers and $2 for ladies. No fees will be required for student members.

The District 12 Prize Paper Competition will be held Tuesday, May 3, in the Garden Room at 9:00 a.m. The winning papers from the Student Branches within the District will be presented and prizes awarded. The first prize is $25 and an all expense trip to the Summer General Meeting at Atlantic City, N. J.; second prize is $20; third prize $15. Student members are invited to participate in all general meetings, inspection trips, luncheons, and dinners.

The ladies headquarters will be in the Hospitality Room which will be open Monday through Wednesday 9:00 to 5:00 p.m.

The following ladies activities have been arranged: Monday, Tuesday, and Wednesday—9:00 a.m. coffee. Monday—1:00 p.m. bridge in the State Suite, Room 1557 of the Sheraton-Biltmore. Tuesday—tour through the Rhode Island School of Design Museum and luncheon. Wednesday—tour through the home of California Artificial Flowers, nationally known manufacturer of artificial flowers.

The following program of inspection trips of both technical and general interest has been arranged for members and guests attending the District meeting.

Brown & Sharpe Manufacturing Company (Monday, 10:00 a.m.)

The Okonite Company—Kennecott Wire & Cable Division (Monday, 2:00 p.m.)

Metals & Controls Corporation, Division of Texas Instruments, Inc. (Tuesday, 1:00 p.m.)

U. S. Navy—Atlantic Fleet Destroyer Force, Newport (Wednesday, 1:00 p.m.)

On Monday evening, a Smorgasbord will be served, and on Tuesday evening, a banquet and entertainment will be held in the main ballroom of the Sheraton-Biltmore.

On Tuesday, May 3, at 2:00 p.m., the District 12 Executive Committee will meet in Parlor C.

Tickets for all events will be available at the registration desk, upper lobby, Sheraton-Biltmore Hotel, open 8:30 a.m. to 5:00 p.m. during the meeting. Delegates are urged to obtain tickets for events they wish to attend as early as possible in order to facilitate arrangements by committees responsible for transportation, luncheon, and dinner reservations.

Mailed Announcement

A mailed announcement of this meeting will be sent to members in District 12. Members in other Districts may obtain a copy by writing to E. C. Day, assistant secretary for technical papers and programs, Technical Operations Department, AIEE, 33 W. 39th St., New York 18, N. Y.

Technical Program

The tentative technical program for the District Meeting follows:

Monday, May 2

9:30 a.m. Session 1—Insulated Conductors

U. S. Atlantic Fleet Photo

A DESTROYER of the post-war Forrest Sherman class, The USS *John Paul Jones* is one of the ships in the Atlantic Fleet Destroyer Force berthed in Newport. An inspection trip to this Destroyer Force has been scheduled for the Northeast District 12 Meeting.

A TOUR to the Kennecott Wire & Cable Division of the Okonite Company will be made during the Northeast District 12 Meeting. The wire drawing operation is shown in this photo.

DP.* Cable Sheaths and Water Permeability. *G. F. Todd*, Collyer Insulated Wire Co.

DP.* High-Temperature Coaxial Cable Developments. *A. L. McKean*, Phelps Dodge Copper Products Corp.

DP.* Vulkene Cable, New Horizons for Polyethylene. *B. J. Mulvey*, General Electric Co.

DP.* Polyethylene on High-Voltage Cables. *R. S. Lovett*, E. I. DuPont de Nemours & Co., Inc.

9:30 a.m. Session 2—Transformers

DP.* Why and How of Auto-Transformers. *L. Reid*, Allis-Chalmers Manufacturing Co.

DP.* Parallel Operation of Regulators and Load-Tap Changing Transformers. *R. F. Gilton*, Allis-Chalmers Manufacturing Co.

DP.* A New Arcing Contact Testing Device. *J. H. Kuisti*, General Electric Co.

DP.* Permalex—New Insulation System for Sealed Liquid Immersed Apparatus. *E. L. Raab*, General Electric Co.

9:30 a.m. Session 3—Industrial and Commercial Power Systems

60-651. Equations for Evaluating Short-Circuit Forces on Multiple-Strap Single-Phase and Polyphase Busses for Supplying Low-Frequency Induction Furnaces. *T. H. Chin*, Westinghouse Electric Corp.

DP.* Inspection Problems of Today's Modern Power Distribution System in Industrial Plants. *J. St. Andre*, Kaiser Aluminum & Chemical Corp.

DP.* Finding Grounds on 3-Phase Ungrounded Systems. *G. Cooper, R. Hurlbut*, General Electric Co.

DP.* Basic Elements of a Grounding System. *E. C. Soares*, Industrial Engineering Services

2:00 a.m. Session 4—Computing Devices (1)

DP.* Recommended Symbols for Logical Design, Part I: Algebraic Symbols. *T. W. Sze*, University of Pittsburgh

DP.* Recommended Symbols for Logical Design, Part II: Symbols for Logic Diagrams. *W. J. Smith*, AFCRC; *D. Drusdow*, Radio Corporation of America

DP.* Recommended Symbols for Logical Design, Part III: Printed Graphical Symbols. *R. J. Preiss*, International Business Machines; *T. C. Bartee*, Massachusetts Institute of Technology

DP.* Recommended Symbols for Logical Design, Part IV: Glossary of Terms. *E. J. Tanana*, Western Electric Co.; *R. Berlin*, General Electric Co.

2:00 p.m. Session 5—Substations

DP.* Modular Structure Design. *F. L. Hecht*, Connecticut Light and Power

DP.* Ground Resistance Measurements of Large Substations. *W. F. Fee*, Hartford Electric Light Co.

DP.* The Development of Voltage Control on the Central Maine Power System. *B. Payne*, Central Maine Power Co.

DP.* Planning Substations to Avoid Noise Complaints. *S. Lindgren*, Allis-Chalmers Manufacturing Co.

DP.* Designing Aluminum Busses. *D. Sandell*, Aluminum Company of America

Tuesday, May 3

9:30 a.m. Session 6—Space Heating

DP.* How the Heat Pump is Used in New England Industries. *J. W. Megley*, Boston Edison Co.

DP.* Industrial and Commercial Space Heating with Radiant Heat. *J. Gialanella*, Quartz Products Co.

9:30 a.m. Session 7—Aluminum Applications in the Electrical Industry

DP.* Short-Circuit Tests on Aluminum and Steel Conduit. *L. F. Roehmann*, Kaiser Aluminum & Chemical Corp.

DP.* How To Connect Aluminum Welding Cable. *R. A. Burkhardt*, Kaiser Aluminum & Chemical Corp.

DP.* Some Practical Aspects on Aluminum Strip Conductors. *H. Adams*, Reynolds Metals Co.

DP.* Aluminum Equipment Terminals. *C. G. Sorflaten*, Ilsco Corporation (formerly with Kaiser Aluminum & Chemical Corp.)

2:00 p.m. Session 8—Electronics

DP.* A New Mode of Operation in Junction Transistors. *N. C. Hekimian*, Department of Defense

DP.* Electronic Load Control for a Small Public Utility Application and Operation Experience. *H. W. Evirs, Jr.*, Fitchburg Gas & Electric Light Co.

DP.* Design Philosophies of D-C High-Gain Low-Drift Transistorized Amplifiers. *J. Kline*, University of Rhode Island

DP.* The Synchronous Electronic Clock. *I. A. Terry*, General Electric Co.

2:00 p.m. Session 9—Computing Devices (2)

DP.* Error Correcting Codes for Correcting Bursts of Errors. *J. E. Meggitt*, International Business Machines Research Laboratories

DP.* Design of a Low-Cost Analog-to-Digital Conversion System for Process Applications. *A. E. Beecher*, Massachusetts Institute of Technology

DP.* Prototype and Special Cams Using the Brown and Sharpe "Numericam" with Tapes Prepared on the IBM *610* Computer. *G. N. Levesque*, Brown and Sharpe Manufacturing Co.

DP.* An Automatic Sheet Classifier. *M. L. Mattheus*, Maxson Automatic Machinery Co.; *G. L. Mathias*, Westinghouse Electric Corp.; and *E. Mojkowski*, Westinghouse Electric Corp.
Information Machine (sound film). *R. Fargnoli*, International Business Machines Corp.

2:00 p.m. Session 10—Rotating Machinery and General Industrial Applications

DP.* Determining D-C Braking Requirements on Continuous Process Rubber Machines. *H. R. Hughes*, Ruberoid Corp.; *H. M. Wall*, Westinghouse Electric Corp.

DP.* A New Adjustable Voltage Drive. *M. J. Girard*, Westinghouse Electric Corp.

DP.* Detection of Shorted Turns in Magnetizing Coils. *W. H. Dorrity*, University of Maine

DP.* Safe Electrical Installations for Textile Plants. *C. F. Hedlund*, Factory Mutual Engineering Division

DP.* A New Look at Paper Mill Lighting. *A. L. Guess*, D. M. Fraser, Ltd.

Wednesday, May 4

9:00 a.m. Session 11—Communications

DP.* Engineering Maintenance in Telephone Transmission. *E. S. Campbell*, New England Telephone and Telegraph Co.

DP.* Chemical Brush Control. *H. F. Hatch, Jr.*, New England Telephone and Telegraph Co.

DP.* Modern Underground Telephone Facilities for New Residential Developments. *G. A. Gardner*, New England Telephone and Telegraph Co.

DP.* Room-to-Room Dialing in a Multistory Hotel. *H. N. Thornton, P. A. Lund*, New England Telephone and Telegraph Co.

9:00 a.m. Session 12—Transmission and Distribution

CP-59-1087. Distribution System Conversion to 4,160 Volts. *L. H. Herendeen*, Jackson and Moreland, Inc.

DP.* Predetermination of Radio Influence Levels of Project EHV Configurations. *J. J. LaForest, A. K. Abboushi*, General Electric Co.

DP.* Determination of the Waves Front of Lightning-Stroke Currents from Field Measurements. *C. F. Wagner*, Westinghouse Electric Corp.

60-658. A New Approach to the Calculation of Lightning Performance of Transmission Lines—III, A Simplified Method. *C. F. Wagner, A. R. Hileman*, Westinghouse Electric Corp.

DP.* Phenomena at the Metal-Dielectric Junctions of High-Voltage Insulators in Vacuum and Magnetic Field. *M. J. Kofoid*, Boeing Airplane Co.

2:00 p.m. Session 13—Special Instruments and Marine Engineering

DP.* Portable Dynamic Electronic Speed-Torque Indicator. *H. R. Weed*, Ohio State University

60-661. The Kine-Klydonograph—A Transient Wave Form Recorder. *S. B. Griscom*, Westinghouse Electric Corp.

DP.* Protection for Underwater Instruments. *H. E. Edgerton, L. D. Hoadley*, Massachusetts Institute of Technology

DP.* Factors in the Evolution of Sophisticated Fire Control Systems for Underwater Weapons. *H. L. Haltermann*, U. S. Naval Underwater Ordnance Station

*District papers will not be printed by the Institute; however, they may be available at the meeting at the discretion of the author.

DP.* The Submarine Threat and Electrical Engineering. *G. G. Gould*, U. S. Naval Underwater Ordnance Station

2:00 p.m. Session 14—Relays and Circuit-Breakers

DP.* Static Overcurrent Trip Device for Low-Voltage Breakers. *N. M. Russak*, Allis-Chalmers Manufacturing Co.

DP.* Backup Protection with an Inoperative Circuit-Breaker. *F. B. Hunt*, New England Electric System

DP.* A Combined Directional Comparison-Voltage Tripping Relay Scheme for a Weak Infeed Transmission Line Terminal. *R. M. Rhoades*, Central Maine Power Co.

DP.* An Application of Transferred Tripping. *G. S. Haralampu, Edward Noorigian*, New England Electric System

AN EXTERIOR view is shown of the National Defense SAC headquarters. A tour to the SAC center will be held during the Rural Electrification Conference.

U. S. Air Force Photo

Under Secretary of Interior To Address Technical Conference

An address by E. F. Bennett, Under Secretary of the Interior, Washington, D. C., will highlight the 1960 Rural Electrification Conference to be held May 10-12 in Omaha, Nebr., at the Sheraton-Fontenelle Hotel.

Mr. Bennett will address the noon luncheon on May 12.

The AIEE has cordially invited all persons interested in the growth of rural mechanization and automation to attend the conference, whose theme will be "The Challenge of Electric Farming."

In general, equipment manufacturers will outline power requirements of present equipment, agricultural engineers and extension personnel will discuss present trends and future possibilities in agriculture, while power suppliers will present plans to meet the ever growing needs of electric power.

Arrangements have been made for a tour of the headquarters of the Strategic Air Command (SAC), including the deep underground Control Center, as well as tours of the Cudahy Packing Plant, the world famous Father Flanagan's Boys Town, and the Omaha Public Power District North Omaha Generating Plant.

Requests for advance registration should be made to: 1960 AIEE Rural Electrification Conference, P. O. Box 721, W. Dodge Station, Omaha 31, Nebr. The sum of $8 should be remitted to cover the cost of registration and luncheon on May 12.

Rates at the Sheraton-Fontenelle Hotel for persons who attend the conference will be:

Rooms (double bed) one person	$ 6.50–$ 9.50
Rooms (double bed) two persons	$10.00–$13.00
Rooms (twin beds) one person	$ 9.50–$12.00
Rooms (twin beds) two persons	$13.50–$16.00
Suites (parlor and one twin bedroom)	$25.00–$32.00

Specific room rates cannot be guaranteed. The hotel will accommodate guests at the requested rate or the nearest available rate. All rooms are completely air conditioned and equipped with private bath, radio, and television.

The tentative program for the conference follows:

Tuesday, May 10

8:00 a.m. Registration—Sheraton-Fontelle Hotel

9:30 a.m. Morning Session
Presiding: R W Shaw

Welcome to Omaha: Mayor John Rosenblatt

Opening Address: J. H. Foote, AIEE president, Commonwealth Services, Inc.

Program for the meeting: W. J. Ridout, Jr., general chairman, AIEE Rural Electrification Subcommittee

CP60-5000. The Revolution in Farming as it Relates to the Electrical Industry. *Fred Kimball*, Kansas Gas & Electric Co.

CP60-5001. Development of and Experience with Nebraska Standards for Electric Irrigation Installations. *R. G. Spore*. Dawson County Public Power District

CP60-5002. Results of Irrigation Motor Power Factor Field Tests. *Dean Axthelm*, College of Agriculture, University of Nebraska

2:00 p.m. Afternoon Session

CP60-5003 Forecasting Power Requirements for Rural Distribution Systems. *Everett Brown*, Rural Electrification Administration

CP60-5004. Planning Rural Systems for Continuing Growth. *C. C. Ambrosius, R. H. Sarikas*, Illinois Power Co.

CP60-5005. Operation Experience with Automatic Outage Reporting on a Rural System. *Karl Crawford*, Lorain Medina Electric Co-operative

CP60-5006. Using 34.5 Kv as a Distribution Voltage. *D. L. Andrews*, Idaho Power Co.

5:00 p.m. Tour No. 1
Bus leaves Sheraton-Fontenelle for SAC Tour

8:15 p.m. Dinner

Wednesday, May 11

9:00 a.m. Morning Session
Presiding: Harry Smith

CP60-5007. New Developments in Automation and Feed Handling. *H. B. Puckett*, University of Illinois

CP60-5008. Drying and Aeration Is Essential to Modern Farming. *J. H. Oliver*, Aerovent Fan and Equipment Co.

CP60-5009. Evaporative Cooling and Air Conditioning for Poultry and Livestock. *Price Hobgood* or alternate, Texas A&M College

CP60-5010. Experience Records of Phase Converters. *L. B. Ronk*, System Analyzer Corp.

CP60-5011. Overcoming the Service and Wiring Bottleneck. *J. B. McCurley*, Rural Electrification Administration

11:30 a.m.—Tour No. 2
SAC (with luncheon)

12:30 p.m.—Tour No. 3
Cudahy Packing Co.

Thursday, May 12

8:45 a.m. Morning Session
Presiding: W. J. Ridout, Jr.

CP60-5012. Changes in the National Electrical Code as it Effects Farmstead Wiring. *H. H. Watson*, General Electric Co.

CP60-5013. Vibration Problems in Rural Line Design. *J. C. Poffenberger*, Preformed Line Products Co.

CP60-5014. A Case History of Line Fatigue. *Ellef Krogen*, Minnkota Power Cooperative

10.25 a.m. Panel—Demands which Farm Electric Equipment Will Put on Power Suppliers in the Future.

CP60-5015. The Demands of the Farmer. *K. L. McFate*, Department of Agricultural Engineering, University of Missouri

CP60-5016. Equipment To Meet the Demand. *C. A. Hanson*, James Manufacturing Co.

Discussion: Led by Lyman Hammond, N.Y. State Electric & Gas Corp.

12:00 p.m. Luncheon
Presiding: R. W. Shaw

Speaker: Elmer Bennett, Under Secretary of Interior, Washington, D.C.

2:30 p.m. Tour No. 4
Boys Town

2:30 p.m. Tour No. 5
Omaha Public Power District Plant

Dibner's "Atlantic Cable" Reviewed by AIEE Past President

Burndy Corp.
Bern Dibner

L. F. Hickernell

IN the exploding rush of new engineering developments today, it is too seldom that we take time to consider, even briefly, the prodigious work and thought which went into the evolution of most of the early engineering achievements. When a present-day engineer becomes interested enough to write of these achievements so that we of the 1960's can read of the labors of past thinkers, it is indeed a happy circumstance.

During the 1930's when Bern Dibner was in Europe, he started to collect scientific memorabilia of all fields but with emphasis on things electrical. Then in 1945, Mr. Dibner wrote and published his first historico-scientific description of Robert Boyle's thinking and works. Since then he has written on a variety of subjects and three of his books dealing with electricity have been published in *Electrical Engineering*[1,2,3] in whole or in part.

Another AIEE Fellow, who is also very much interested in the history of electricity, is Past President L. F. Hickernell, who wrote profusely on the early days of the Institute in a series of articles which were published during the 75th Anniversary Year in *Electrical Engineering*. Mr. Hickernell has reviewed Mr. Dibner's latest book "The Atlantic Cable," and it is with pleasure that we republish this review. Reprinted from *Technology and Culture*, The International Quarterly of the Society for the History of Technology, by permission of the Wayne State University Press. Copyright, 1960, Wayne State University Press.

The Atlantic Cable. By Bern Dibner. Publication No. 16, Burndy Library in the History of Science Inc., Norwalk, Conn., The Burndy Library, 1958. Pp. 96. Illustrated.

Bern Dibner has written a lucid chronological history of the laying of the Atlantic Cable. He covers the early experiments of Morse in New York Harbor in 1842; Ezra Cornell's laying of a line across the Hudson River in 1845; the five actual attempts at laying the cable; and the eventual success in completing two telegraph circuits connecting Newfoundland and Ireland in 1866. Written a century after the initial expedition set forth in 1857, distance in time permits the placing in perspective of all phases of accomplishment of a great engineering achievement.

Cyrus Field was, in the words of Sir William Thomson (later Lord Kelvin), the "originator and mainspring" of the project, which was regarded as foolhardy in many quarters. At the outset in 1854, Field realized that many electrical, mechanical, oceanographical, and nautical problems would have to be solved. Having sought and obtained encouragement of specialists in each of these areas, he was able to raise the necessary capital to finance the design, manufacture, transportation, and laying of the submarine telegraph cable. Field did not foresee, however, that the enterprise would take twelve years and forty long, hazardous trans-Atlantic crossings (the first by sailing vessel); that it would touch the fields of science, politics, finance, and geography; and that it would cost $12,000,000.

This book makes clear the roles of Field and Morse and Thomson, of the ships' captains and the financial backers, and of all those who played a part in the courageous undertaking. Brief biographical footnotes keep the reader informed about the principals as the saga unfolds. The author is a tireless researcher, and his work is carefully documented. It is also immensely readable and suspenseful.

Technical difficulties and incredible hardships plagued the men who sought to lay the cable. Time after time, their hopes were gradually raised, then dashed suddenly by a heartbreaking mishap. Yet each time, they made new plans and began again. Every failure seems almost to have been a necessary step toward eventual success. The reader shares a sense of triumph when he comes upon these words in Field's message from Trinity Bay to New York on July 27, 1866: "Thank God, the cable is laid, and it is in perfect working order."

But the story does not end there. Within five days, the expedition had turned back into the Atlantic to attempt to retrieve cable lost the previous year, which lay 600 miles away in two and a half miles of water. Three weeks later, the cable was brought to the surface for the first time, only to part and splash back into the ocean. Thirty attempts were to be made before the cable was successfully raised on August 31st. It was tested and spliced to another length, which was laid on the return voyage to Trinity Bay. Thus, the second Atlantic telegraph circuit was completed.

The monograph is concise, almost synoptic, and condenses into 96 pages material which easily could be expanded into a full-length book. Experiences in the Newfoundland wilderness could alone fill a chapter.

Mr. Dibner's pages are generously sprinkled with illustrations of historical and engineering interest, including a photograph attributed to Daguerre, Paris, 1845. There are reproductions of etchings, paintings, drawings, and documents. Most enlightening of all is a two-color map and chart insert which shows simply and clearly the chronology of expeditions and the locations of their terminations.

This is an irresistible and inspiring story of man's vision, perseverance, and triumph over the forces of nature; over human nature, too. Those who are familiar with the electrical engineering milestone it describes will find in the book a neat summation. Those who have yet to become acquainted with the details will find it rewarding reading indeed. Incidentally, the book should be required reading for America's young people. They would find it surprisingly palatable fare.

The Atlantic Cable, as presented by Bern Dibner, leaves one with the conviction that any problem which a number of informed and dedicated men working together believe can be solved, inevitably will be. By drawing a simple parallel, one sees that man's exploration of space is certain of accomplishment.

L. F. HICKERNELL

1. "10 Founding Fathers" was a 10-part article which appeared April 1954–January 1955.

2. "Early Electrical Machines" was published May–October 1957 in six parts.

3. "The Atlantic Cable" appeared in three parts, September–November 1959.

Abstracts of Papers Invited for Quality Control Symposium

Abstracts of papers to be submitted for the 7th National Symposium on Reliability and Quality Control, jointly sponsored by the AIEE, the Institute of Radio Engineers, and the American Society for Quality Control, must be received by May 16, 1960. The symposium is scheduled for January 9-11, 1961, at the Bellevue-Stratford Hotel, Philadelphia, Pa.

Ten copies of the abstract, of not more than 800 words, are required. It should include the title of the paper (not to exceed 50 letters, including spaces), the author's name, position, and affiliation. In the case of more than one author, please indicate who will present the paper. Ten copies of a biographical sketch of each author (suitable for publication in the Proceedings) must accompany the abstract.

Authors will be notified of acceptance by June 27, 1960. Final papers will be due October 10, 1960. Submit abstracts and biographical sketches to R. E. Kuehn, IBM, Owego, N.Y.

Basic Sciences Committee Sponsors First MHD Symposium

Magnetohydrodynamics (MHD) was the subject of a 2-day symposium at the University of Pennsylvania recently.

MHD has gained its present stature because of increased scientific inquiry into the control of nuclear reactions for peaceful purposes and because of its possible applications to such fields as space travel and communications.

In trying to harness the extremely high temperatures of nuclear reactions, scientists cannot depend on any known containers. They must use, for example, magnetic fields to help force these reactions to stay within bounds.

So far, MHD has been put to limited use in providing electricity. This was done by forcing a plasma stream at high speed between electrodes (at right angles to a magnetic field), and extracting electricity, by means of the free electrons in the plasma, as the plasma flows between the electrodes.

This and other subjects were covered in the power conversion session.

Other potential uses, discussed in the flight applications session, included controls for space vehicles, testing equipment for aero/space vehicles, and many other possibilities.

Sponsored by the Basic Sciences Committee, AIEE, this first MHD symposium —with sessions on communications and diagnostics, power conversion, fusion, and flight applications—included 37 papers read by top-flight representatives from universities, research foundations, and private industry.

Among the topics discussed at the symposium were: how to get radio waves to travel through a plasma sheath, the best types of MHD power-conversion units, the problems of controlled thermo-nuclear fusion, and the possibilities of using MHD power in space.

PARTICIPANTS in the communications and diagnostics session at the MHD Symposium assemble on the steps leading to the University of Pennsylvania museum. They are *(left to right)*: M. Lessen and J. Jarem, University of Pennsylvania; L. Goldstein, University of Illinois; W. E. Hill, General Electric; W. G. Dow, University of Michigan; M. S. Sodha, Armour Research Foundation; J. L. Hirshfield, Massachusetts Institute of Technology; H. L. Bunn, Livermore Radiation Laboratory; and G. Bekefi, Massachusetts Institute of Technology. Not shown is M. A. Heald, Swarthmore College, who read the invited paper for the session.

Telemetering Conference Is Scheduled for May 23-25

"Telemetry—Tool for Industry and Defense" will be the theme of the 1960 National Telemetering Conference (NTC), to be held May 23-25, 1960, at the Miramar Hotel in Santa Monica, Calif.

Sponsoring societies are: AIEE; Instrument Society of America, which is the 1960 host; American Rocket Society; Institute of Aeronautical Sciences; and Institute of Radio Engineers.

Hugh Pruss of Telemetering Corporation of America, chairman of the 1960 conference, has announced that plans are shaping up well for the biggest NTC meeting in the conference's history.

Roy Colander, program chairman, has selected 71 outstanding technical papers which will be presented in panel form in 16 separate sessions running 3 sessions concurrently. In addition, 2 dynamic workshop sessions are scheduled.

The latest in telemetry equipment and techniques will be displayed by leading manufacturers for both industry and the military. More than 66 exhibit booth spaces have been provided in two large halls. In addition to the banquet and cocktail party, several interesting tours are planned for both conferees and wives.

Tentative session topics are as follows:

Monday, May 23

Morning Sessions

Industrial Data Transmission Systems
Biomedical Measurements
Space Data Acquisition Systems

Afternoon Sessions

General R-F Components and Techniques
Missiles and Aircraft Telemetry Workshop—"R & D Needed in the 60's"
Data Processing and Presentation—I

Tuesday, May 24

Morning Sessions

PCM Progress
General—Transducers
Ground Stations—New Components and Techniques

Afternoon Sessions

Industrial Supervisory Control
Missiles and Aircraft—Flight Data Systems
Telemetry Techniques—I

Wednesday, May 25

Morning Sessions

Data Processing and Presentation—II
Missiles and Aircraft—Environment Measurement
General Transistorization Progress

Afternoon Sessions

Industrial Telemetry Workshop—"What We Really Need Is—."
Telemetry Techniques—II
Reliability in Telemetry

Additional information may be obtained by contacting Mr. Pruss at 8345 Hayvenhurst Ave., Sepulveda, Calif.

Appliance Conference Technical Papers Are Listed

The 11th annual AIEE Appliance Technical Conference, which is sponsored by the Subcommittee on Domestic Appliances and the AIEE Mansfield, Ohio, Section, will be held in Mansfield, Ohio, May 16-17, 1960, with headquarters at the Mansfield-Leland Hotel.

The theme of the conference will be "The Appliance Industry—Its Philosophy Position for the Years Ahead and the Role Technology Should Play." The papers will reflect engineering parameters of interest to designers of all types of appliances and a roundup of current new engineering designs. A panel will discuss quality, reliability, and service concepts in appliance engineering and manufacture.

Mansfield has a good cross section of plants making major appliances, electric housewares, and control devices. Tours have been arranged so that it will be possible for each attendee to take two tours without missing technical sessions.

Advance program and advance registration forms will be mailed to all engineers who have attended the conferences in pre-

vious years. Others desiring to receive the advance mailing should advise R. H. Risser, Ohio Brass Company, Mansfield, Ohio.

The tentative program of papers to be delivered follows:

Mechanical Problems of Electric Contacts and Connections. *L. Flenner*, Thermo-O-Disc

Standardizing Small Motors. *E. Howell*, International General Electric Co.

Matching Motors to Appliance Loads. *J. C. Burdett*, Westinghouse Electric Corp.

Ultrasonics in Fabric Washing. *L. Johnson*, Westinghouse Electric Corp.

Thermoplastics in Appliance Design *G. Thayer*, Dow Chemical Co.

Specifying Centrifugal Pumps for Appliance Applications. *V. K. Steidley*, Gorman-Rupp Industries, Inc.

Magnetic Door Closures for Refrigerators and Freezers. *R. L. Bootes*, General Electric Co.

Calibration and Quality Control Testing of Thermostats. *W. C. Stevens*, Stevens Manufacturing Co.

Control System Design for Refrigerators. *J. Liebermann*, Ranco, Inc.

Engineering Audit of Design Quality *G. Schroeder*, General Electric Co.

Positive Quality Control. *C. Wood*, Whirlpool Corp.

Customer Service—A Technical "Feedback" for Engineering and Quality Control. *H. L. Gross*, Sears, Roebuck & Co.

A Hard Coating Process for Aluminum. *J. J. Snegoski*, Toro

A Simple Plastic Part Fabricating Process. *Mr. McFarland*, Scott & Fetzer Co.

A Nontimed "Proportional Dryer Control." *N. Fuqua*, Thermo-O-Disc

An Automatic Surface Unit Control for Ranges. *C. Holtkamp*, Westinghouse Electric Corp.

Combining Microwave and Infrared Cooking in a Single Oven Cavity. *S. Johnson*, Westinghouse Electric Corp.

An Immersible Percolator Design. *D. Price*, Westinghouse Electric Corp.

Rubber and Plastics Conference Program Given

The 12th Annual Rubber and Plastics Conference of the AIEE Rubber and Plastics Industries Subcommittee will be held April 25-26, 1960, in Akron, Ohio, at the Sheraton Hotel.

The tentative program for the conference follows:

Monday, April 25

8:00 a.m. Registration

Coffee and Doughnuts

9:00 a.m. Morning Session

Presiding: E. L. Smith

Keynote Address: "Rubber Processing Techniques." A. S. Miller, manager, Plant One Laboratory, Firestone Tire & Rubber Co.

Automation of Tire-Handling Systems. *Clinton Ivins*, Airborn Instrument Laboratories

Prepared Discussion. *R. J. Donze*, Goodyear Tire & Rubber Co.

Prepared Discussion. *Mr. Shively*, B. F. Goodrich Co.

12:00 noon. Luncheon Recess

2:30 p.m. Computer Session

Presiding: C. E. Robinson

Programming Scientific Problems on D-C Computers. *J. R. Hopkins*, Monsanto Chemical Co.

Prepared Discussion. *C. D. Beck*, General Electric Co.

Prepared Discussion. *Irving Lefkowitz*, Case Institute of Technology

Trend Toward Miniatured Industrial Controls. *C. W. Hibscher*, Toledo Scale Co.

Prepared Discussion. *Wayne Bebb*, Goodyear Tire & Rubber Co.

Prepared Discussion. *A. G. Seifried*, B. F. Goodrich Co.

Tuesday, April 26

8:30 a.m. Coffee and Doughnuts

9:00 a.m. Instrumentation Session

Presiding: R. P. Bleikamp

Sensing Devices for Automatic Machinery Control. *J. R. McCarthy*, Firestone Tire & Rubber Co.

Prepared Discussion. *C. E. Blumenauer*, U.S. Rubber Co.

Infrared Temperature Measurements. *R. H. Kennedy*, Bristol Co.

Prepared Discussion. *S. G. Gehman*, Goodyear Tire & Rubber Co.

Web Guiding Devices. *Ed Hunter*, Goodyear Tire & Rubber Co.

Prepared Discussion. *Mike Bliven*, Goodyear Tire & Rubber Co.

12:00 noon. Luncheon Recess.

Subcommittee members will have a private luncheon meeting.

2:30 Rotating Machinery Session

Presiding: N. A. Williams

Mechanical Considerations in the Design and Installation of Large Electrical Equipment. *B. B. Winer*, Westinghouse Electric Corp.

Prepared Discussion. *J. A. Bell*, Adamson United Co.

Static Application of Excitation to Synchronous Motor Fields. *R. M. Hayford*, Westinghouse Electric Corp.

Prepared Discussion. *Robert Greenham*, Timken Roller Bearing Co.

Prepared Discussion. *A. Ewy*, Allis-Chalmers Manufacturing Co.

Report of Working Group on Recommended Practices for Rubber and Plastics Industries. *W. S. Watkins*, Ohio Rubber Co.

Textile Industry Conference Is Scheduled

The Textile Industry Subcommittee of the AIEE will hold its annual Conference on Electrical Application in the Textile Industry at the Heart of Atlanta Motel, Atlanta, Ga., on May 5-6, 1960.

This conference is designed to bring together managers, engineers, technicians, and master mechanics of the textile industry to discuss mutual points of interest concerning the electrical phases. Application of new and old equipment will be discussed along with the design, operation, and maintenance of the equipment.

Eight papers are scheduled tentatively for presentation. The papers are as follows:

Connections and Maintenance of Transformers. *J. W. Nims*, Chemstrand Corp.

Applications Committee Report concerning Higher Temperatures for Electric Equipment. *Ray Parker*, chairman, Applications Panel

Research—Road to Progress. *M. F. Martin*, General Electric Research Laboratory

Static Power Conversion Techniques and Applications. *R. P. Putkovich*, Westinghouse Electric Corp.

New Electrical Applications through Textile Research. *J. C. Hogg, Jr.*, West Point Manufacturing Co.

Some Do's and Don'ts of Electrical Grounding in a Textile Plant. *L. S. Inskip*, Bell Telephone Labs.

How Textile Mills Can Profit from the New Recommended Practices. *F. D. McConnell*, Southern Electrical Equipment Co.

Experience of Insurance Inspectors with Emphasis on Improper Electrical Practices in Mills. *W. A. Weddendorf*, Mutual Boiler & Machinery Insurance Co.

This program will be presented from 10:00 a.m. until 5:00 p.m. on Thursday and from 9:00 a.m. until noon on Friday. A luncheon, social hour, and a banquet will be included in the program on Thursday.

Call for Papers Issued by Computing Devices Committee

Prospective authors are invited to submit papers on significant work dealing with the "Organization of Large Volume Data-Processing Systems."

This call for papers has been issued by the Computer Systems Subcommittee of the AIEE Computing Devices Committee for presentation at the AIEE Fall General Meeting in New York, N. Y., on October 9-14, 1960.

Papers should deal with the economics and design for total system optimization, encompassing data gathering, digital data transmission, the processor(s), and data dissemination. Prospective authors may submit papers on:

1. Identifying the basic parameters involved in describing "large volume systems" and relating these parameters as criteria for systems organization and equipment selection for given situations—both actual and theoretical.

2. Effect of digital communication trends on the organization of processors.

3. Delineating areas of relative economic advantage of centralized and decentralized data processing.

4. The impact on system economics and mechanizations of advanced processing devices and systems organizations evolving from research.

Abstracts of prospective papers are needed almost immediately to allow for the selection and preparation of the program for these special sessions. Strict adherence to the following schedule is essential:

April 1—Deadline for receipt, in tripli-

cate, of a 50 to 100-word abstract and a 500-word summary of the paper.

May 2—Notification of paper selection and request for complete papers.

June 10—Deadline for full text of *Transactions* papers prepared in accordance with the AIEE Author's Guide.

August 5—Deadline for full text of conference papers. (Preprints only)

All correspondence concerning these special meetings should be addressed to: C. S. Dilks, associate director, Burroughs Corporation, Research Center, Paoli, Pa.; or G. W. Bills (paper chairman), North American Aviation, Inc., Missile Division 495-24, 12214 Lakewood Blvd., Downey, Calif.

AIEE Subcommittee Holds Quarterly Working Group Meeting

The Ground Support Electric Systems Integration Subcommittee of the AIEE Aero-Space Transportation Committee held its quarterly working group meeting at the Martin Company facilities in Orlando, Fla., February 16-19, 1960.

Preparation of a technical paper to be presented at the Electrical Engineering in Space Technology Conference during April in Dallas, Texas, as well as a review of the five committee-sponsored papers for the Pacific General Meeting in August, were the main items of business. In addition, the Committee members were guests of the U. S. Air Force Missile Test Center at Cape Canaveral for an inspection of the various support electric power installations of the missile launch sites.

The working groups within the committee reported progress in their assignments to investigate the role of support power, and anticipate an early release of guides and suggestions for improving quality and types of power, such that a true integration function may result.

The next meeting of the committee will be held in San Diego, Calif. at the Pacific General Meeting in August.

Automatic Techniques Conference To Be Held in April

For the third consecutive year, the AIEE, the American Society of Mechanical Engineers (ASME), and the Institute of Radio Engineers (IRE) will co-sponsor the Joint Automatic Techniques Conference. The 1960 conference will be held April 18-19 in Cleveland, Ohio, at the Sheraton-Cleveland Hotel.

This conference draws upon the experiences of a variety of industries, obtaining both a general outline of certain problems that have confronted the industries and a discussion of the automatic techniques and the reasoning applied in solving the problems. Dealing broadly with techniques that have proved successful in solving practical problems, the conference appeal cuts across both industry classifications and job function categories.

Conducting the conference will be the following:

ATTENDING the Ground Support Electric Systems Integration Subcommittee meeting were: *(left to right)* Ralph Hopkins, U. S. Army; J. S. Young, Douglas Aircraft; Frederick Strum, Boeing Aircraft; Major John Parsons, U. S. Army; J. I. Elliott, Martin-Baltimore; Glyn Williams, Hobart Brothers; and Carl Geib, Ideal Electric.

National Steering Committee—F. D. Snyder, Westinghouse Electric Corporation (AIEE); Mead Bradner, Foxboro Company (ASME); J. E. Eiselein, Radio Corporation of America (IRE)

National Program Chairman: L. W. Herchenroeder, Westinghouse Electric Corporation (ASME)

Cleveland Conference Co-chairmen: J. W. Picking, Reliance Electric & Engineering Company (AIEE); R. W. Bolz, *Automation* (ASME); Warren Jackson, Standard Oil Company (IRE)

The tentative technical program follows:

Monday, April 18

Session I—Automatic Manufacturing

Metal Forming Under Electronic Sequencing. *E. F. Crane*, E. W. Bliss Co.

Automatic Assembly. *J. F. Stoltz*, Hawthorne Works, Western Electric Co.

Numerical Control Developments. *R. G. Chamberlain*, Giddings & Lewis Machine Tool Co.

Session II—Automatic Inspection and Quality Assurance

Automatic Gaging. *H. L. Boppel*, Sheffield Corp.

CP60-595. Production Line Testing Programmed by Punched Cards. *R. E. Wendt, Jr.*, Westinghouse Electric Corp.

Airframe Structural Integrity Testing. *R. L. Bondurant, D. W. Jackson*, Wright Air Development Center, Wright-Patterson Air Force Base.

Session III—Computer Control for Utility and Process Industries

CP60-596. The Operational Information System and Automation at Sterlington Steam Electric Station. *J. A. Reine, Jr.*, Louisiana Power & Light Co.

Problems Encountered and Solved in Starting of Computer Controlled Systems. *W. F. Aiken*, Thompson-Ramo-Wooldridge Products Co.

User-Supplier Relationship in Automating a Steel Rolling Mill. *C. W. Burdick*, Lukens Steel Co.; *N. L. Weckstein, R. A. Hamilton*, General Electric Co.

Tuesday, April 19

Session IV—Automatic Warehousing

CP60-648. Automatic Baggage Handling. *H. C. Warrington*, United Air Lines.

CP60-597. Automatic Technique in Book Warehousing and Shipping. *J. B. Bennett, Jr.*, Macmillan Co.

CP60-598. Automatic Warehousing Facilities at C and H Sugar Refining Corp. *D. C. Gutleben*, California and Hawaiian Sugar Refining Corp.

Railroad Conference Sponsored by AIEE-ASME

The Railroad Conference, sponsored by the AIEE and the American Society of Mechanical Engineers (ASME), will be held April 20-21, 1960, in Pittsburgh, Pa., at the Penn-Sheraton Hotel.

Registration will take place on Wednesday, April 20, from 8:00 a.m. to 5:00 p.m., and Thursday, April 21, from 8:00 a.m. to 2:00 p.m., at the Monongahela Room Corridor, 17th floor. The fee for the conference will be $4 for members of AIEE or ASME, and $6 for nonmembers.

By invitation, the authors, session chairmen, and vice-chairmen will meet at breakfast to become better acquainted and receive last minute instructions. The breakfasts will be served at 8:00 a.m. each day of the conference in Parlor E, 17th floor.

An all-committee meeting will be held April 19 at 4:00 p.m. in Parlor G, 17th floor.

No formal ladies program has been planned. However, the Women's Auxiliary will be present to assist in planning informal activities if desired.

Luncheon costs on each day will be $4.50 per person.

For advance registration, checks should be made payable to "Pittsburgh Section—ASME" and sent to: G. M. Gabble, Jr., Westinghouse Air Brake Co., Wilmerding, Pa.

The tentative technical program for the conference follows:

Wednesday, April 20

9:30 a.m. Session I

The Slippery Spot Concept of Adhesion. *J. C. Aydeloti*, General Electric Co.

Study of the Defects in Railroad Wheel Treads. *J. M. Wandrisco, F. J. Dawes*, U. S. Steel Research Center.

Forces between Wheel and Rail. *F. F. Olson*, Swedish State Railroads.

2:00 p.m. Session II

Modern Ore Unloading. *R. C. Tench*, C&O Railroad.

TP60-602. French Technical Advances in the Field of Railroad Electrification. *F. Nouvion*, French National Railroads.

Railroad Electrification in Poland. *J. Podoski*, Warsaw, Poland.

Thursday, April 21

9:30 a.m. Session III

CP60-599. Locomotive Repair Costs and their Economic Meaning to the Railroads of the United States. *H. F. Brown*, consulting engineer, New Haven, Conn.

TP60-600. Electric Locomotive Maintenance Cost Equation. *J. W. Horine*, Pennsylvania Railroad.

Spectographic Analysis of Diesel Engine Lubricating Oils by the Rotating Platform Method. *J. G. Smith*, General Electric Co.

2:00 p.m. Session IV

Automation in Railroading. *V. E. McCoy*, Chicago, Milwaukee, St. Paul & Pacific Railroad.

Automated Testing of Railway Freight Brake Equipment. *P. W. Brath, E. T. Skanter*, Westinghouse Air Brake Co.

CP60-601. Air Cleaning Features for Traction Equipment. *P. G. Lessman*, Westinghouse Electric Corp.

AIEE Announces Fortescue Fellowship Award

The Charles LeGeyt Fortescue Fellowship Committee of the Institute has awarded a Fellowship for graduate study in electrical engineering during the academic year 1960-61 to Jeffrey Frey.

Mr. Frey was born in New York City on August 27, 1939. He graduated from Samuel J. Tilden High School in Brooklyn in 1955, and entered the School of Electrical Engineering at Cornell University.

As evidence of his interest in electronics while in high school, Mr. Frey designed and built high-fidelity equipment and various electronic gadgets. At Cornell, he has compiled an impressive record of scholastic achievement. Utilizing the flexibility afforded the student by Cornell's 5-year engineering program, he has chosen technical electives in the fields of mathematics, electromagnetic waves, and microwave theory, as well as in philosophy and music.

Mr. Frey ranks first in the graduating class of the College of Engineering at Cornell. He has been a staff engineer for WVBR, the Cornell FM broadcasting station, and was the illustrations editor of the undergraduate technical magazine, *The Cornell Engineer*, from 1957 to 1959. He received second prize in the 1958 McGraw-Hill contest for the best nontechnical article appearing in any college technical magazine.

Jeffrey Frey

Mr. Frey received the local Eta Kappa Nu award as "Outstanding Scholar of the Sophomore Class," and was elected to the Kappa chapter of Eta Kappa Nu in his junior year. He was corresponding secretary, later president, of that organization, served on its Curriculum Revision Suggestions Committee, and is now a member of its Annual Report Committee. Mr. Frey was elected to New York Delta of Tau Beta Pi as an honor junior and is currently vice-president of the chapter. He has recently been elected to the Cornell Chapter of Phi Kappa Phi.

Mr. Frey is now the vice-chairman of Cornell's AIEE-IRE (Institute of Radio Engineers) Joint Student Branch, and has further served local electrical engineering interests by acting on his school's Engineers' Day Committee in 1959.

During the Summer of 1958, Mr. Frey worked as an assistant engineer at Radiation, Inc., in Melbourne, Fla. In this position, he was concerned with the development and installation of an automatic tracking telemetry antenna. During the Summer of 1959, he worked at Wilton-Fijenoord, N.V., in Schiedam, Holland, as part of the program sponsored by the International Association for the Exchange of Students for Technical Experience. His interest in microwave electronics is a result of his ultimate contact with the field through his 5th-year project, a study, under Prof. L. F. Eastman of Cornell, of radial motions in electron beams that are not in confined flow.

Mr. Frey has been awarded many undergraduate scholarships. He received the New York State scholarship, the Cornell-State scholarship, various awards presented through the College of Engineering at Cornell, and the I-T-E Foundation Award, for both 1958-59 and 1959-60. This year, he is teaching assistant in the School of Electrical Engineering, instructing in 3d- and 4th-year basic electronics courses.

Mr. Frey plans to pursue his interest in microwave electronics at the University of California, at Berkeley.

G. D. Lobingier, of the Westinghouse Electric Corporation, East Pittsburgh, Pa., is chairman of the committee administering the award for the Institute.

The Fellowship was established in 1939 by the Westinghouse Electric and Manufacturing Company (now Westinghouse Electric Corporation) as a memorial to Charles LeGeyt Fortescue for his contributions to the electric power industry.

Dr. Fortescue, who was graduated from Queens University, Kingston, Ont., Canada, as the university's first electrical engineer in 1898, received 185 patents on electrical inventions during his 38-year career with Westinghouse.

Winners Announced of Prize Paper Competition

The winners of the AIEE District Prize Papers Competition have been announced. The first prize for any Transactions paper prepared by a resident of the District consists of a certificate and $75; the second prize is a certificate and $50.

District 1:

First Prize—Progress in Extra-High-Voltage Power Transmission. *P. A. Abetti, S. B. Crary*

Second Prize—Wave Propagation along Unbalanced High-Voltage Transmission Lines. *G. E. Adams*

District 2:

First Prize—A New Approach to the Calculation of the Lightning Performance of Transmission Lines—II. *C. F. Wagner, A. R. Hileman*

Second Prize—Recurrance Relations in the Solution of a Certain Class of Nonlinear Systems. *A. A. Wolf*

District 3:

First Prize—Transmission Properties of Polyethylene Insulated Telephone Cables at Voice and Carrier Frequencies. *G. S. Eager, Jr.; L. Jachimowicz, I. Kolodny, D. E. Robinson*

Second Prize—Binary Communication Feedback Systems. *B. Harris, A. Hauptschein, K. C. Morgan, L. S. Schwartz*

District 4:

First Prize—Iron Loss Calculations on Fractional Horsepower Induction Motors. *P. H. Trickey*

Second Prize—Digital Computer Applied to Electrical Distribution System Planning. *E. A. Strausser*

District 5:

First Prize—A New Stator Coil Transposition for Large Machines. *W. L. Ringland, L. T. Rosenberg*

Second Prize—A High-Capacity Maintenance-Free Generating System for Motor Coaches. *R. L. Larson*

District 6:

First Prize—The *X/R* Method of Applying Power Circuit Breakers. *J. E. Skuderna*

Second Prize—An Automatic Speed Control System for a Gravity Freight Classification Yard. *R. J. Berti, T. J. Dosch*

District 7:

First Prize—Selecting Damping Resistors

for Vacuum Switches in Bank to Bank Switching. *J. Zaborszky, J. W. Rittenhouse, E. L. Luehring*

Second Prize—Heating of Induction Motors on Unbalanced Voltages. *B. N. Gafford, W. C. Duesterhoeft, C. C. Mosher III*

District 8:

First Prize—Complex-Zero Signal Generator for Rapid System Testing. *G. G. Lendaris, O. J. M. Smith*

Second Prize—Field Testing of a 69-Kv Oil Circuit Breaker by the Southern California Edison Company. *P. C. Edwards, P. Q. Nelson*

District 9:

First Prize — Constant-Frequency Variable-Speed Frequency-Make-Up Generators. *B. V. Hoard*

Second Prize—Shunt Coupled Magnetic Amplifier Circuits. *R. M. Hubbard*

District 10:

First Prize (only)—Type *OJ* Carrier Telephone System. *J. A. Coy, E. S. Kelsey, B. P. Nichols*

District 11:

First Prize—Solar-Powered Thermal Electric Generator Design Considerations. *N. F. Schuh, R. J. Tallent*

Second Prize—Auxiliary System for a Supercritical Unit: A Design Based on a Tested System for a Subcritical Unit. *J. P. Fitzgerald, G. F. Paulus, H. A. Vargas*

District 12:

First Prize—Correlation of Forced and Free Oscillations of Coils and Windings. *P. A. Abetti*

Second Prize—Eddy-Current Losses in Solid and Laminated Iron. *P. D. Agarwal*

Proposed Nuclear Plant Described at Michigan Meeting

J. H. Campbell, senior vice-president of Consumers Power Company, spoke on the company's proposed nuclear power plant at the February 9, 1960, meeting of the Michigan Section, AIEE.

Consumers Power Company plans to build a boiling water nuclear power plant on Lake Michigan at Big Rock Point, Hayes Township, Charlevoix County, Mich. The reactor will be of the direct cycle, forced circulation, boiling water type with a maximum expected gross electrical capability of 75,000 kw. When completed, Consumers will make the plant available for a period of approximately 4½ years for the conduct of a defined program of research and development, aimed primarily at the development of nuclear reactor cores having a high power density, long life, and low fabrication cost.

Mr. Campbell discussed the proposed plant, and Consumers' role in the proposed research and development program.

During the meeting, AIEE President J. H. Foote was presented with a Certificate of Appreciation for serving as chairman of the AIEE Administration Department for 1958-59.

Another item of business was the presentation of a $1,000 check from the Michigan Section, AIEE, to the United Engineering Center (UEC) Building Fund.

W. J. Barrett Cited by Brooklyn Polytechnic Alumni

W. J. Barrett (M '36, F '50), transmission maintenance engineer of the New Jersey Bell Telephone Company, Newark, N. J., and past president of the AIEE, has been cited by the Alumni Association of the Brooklyn Polytechnic Institute for outstanding service to the engineering profession as illustrated by his work in the AIEE and for being past president of the United Engineering Trustees.

The presentation was made at the 97th annual alumni banquet.

The citation stated:

"Brooklyn Polytechnic Alumni Association holds that a college education should be the training and inspiration for the future of mankind and service to the community, the nation, and humanity, and that men and women in accepting the privilege of a college education also assume the obligation to society to exercise leadership in those civic and professional activities that are essential to a democracy.

"Walter J. Barrett, an alumnus of the Polytechnic Institute of Brooklyn, having in the judgement of the Alumni Association demonstrated a practical acceptance of these responsibilities and obligations by his public spirited citizenship, is hereby deemed as a worthy alumnus and herewith awarded the alumni citation of useful citizen.

"In making this citation, the Alumni Association acknowledges, with pride, the service of this alumnus which has reflected credit upon our Alma Mater and its alumni."

Poch Bros. Photo

W. J. Barrett

Mr. Barrett has served the AIEE as president (1957-58), treasurer (1953-57), and director (1949-52). He has been a member of the following AIEE Committees: John Fritz Medal Board (1958-62); Edison Medal (1958-60); Board of Trustees, United Engineering Trustees, Inc. (1951-58, president 1955-56); Joint AIEE-IRE Co-ordination (1951-55, 1957-58, chairman 1953-55); and Finance (1949-52, chairman 1950-52).

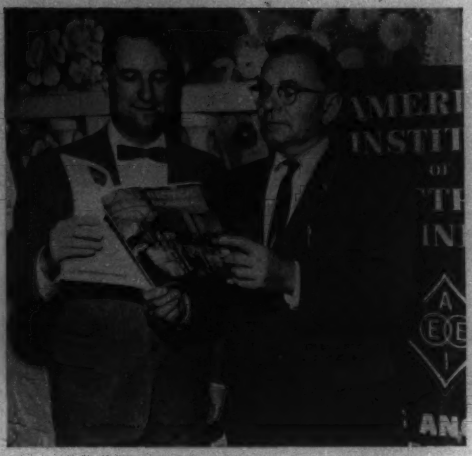
Noted British Engineer and Wartime Hero Dies in London

Arthur Clifford Hartley, president of the British Institution of Civil Engineers, died in a London, England, hospital on January 28, 1960, at the age of 71.

Mr. Hartley was the developer of the "fido" airfield fog clearing system during World War II and a winner of the United States medal of freedom. He helped develop an undersea pipeline to carry gasoline from Britain to the allied invasion forces in France.

During World War I, he served as a major in the Royal Flying Corps. He was credited then with aiding development of a device to time the firing of a fighter plane machine gun so that it could be fired through the propeller without shattering the propeller blades.

PRESENTATION of a $1,000 check from the Michigan Section, AIEE, to the UEC Building Fund was made at a Section meeting. B. H. Schneider (*center*), Section chairman, gave check to H. M. Hess (*left*), chairman of the UEC Fund Drive in the Michigan Section. J. H. Foote (*right*), AIEE president, was present at the meeting.



PROJECT EHV was the subject of Dr. P. A. Abetti's talk at a recent dinner meeting of the Los Angeles Section, AIEE. Discussing an article in *Electrical Engineering* are: (*left to right*) Dr. Abetti and Fred Foulon, Section chairman.

Rothschild Photo

Project EHV Discussed at Los Angeles Section Meeting

Dr. P. A. Abetti, authority on extra-high voltages, has forecast 700,000-volt power transmission lines by 1975. The prediction was made at a recent dinner meeting of the Los Angeles Section, AIEE.

One of the most challenging engineering goals expected to be accomplished in the next 10 to 20 years is the application of extra-high voltage to the nation's electric power transmission systems. The probable next step in voltage in the United States will be 460 kv to be introduced about 1962. A higher voltage of the order of 650 to 690 kv may be introduced about 1975.

Dr. Abetti (AM '49, M '55) is manager of Project EHV, which was launched in 1959 by the General Electric Company in Pittsfield, Mass. He described the technical plan of Project EHV and the reasons for the choice of its principal system characteristics.

AIEE President Visits Beaumont, Texas, Section

The Beaumont Section, AIEE, was host to J. H. Foote, AIEE president, on January 14, 1960.

A luncheon was given for Mr. Foote and AIEE Vice-President I. T. Monseth at the Lamar State College of Technology which is located on the edge of the city of Beaumont.

Following the luncheon, Mr. Foote was taken on a guided tour of Lamar State College which is currently undertaking a building program and enlarging the curriculum. Mr. Foote addressed a group of senior electrical engineering students on the bright future in prospect for the electrical engineering student.

Late in the afternoon, Mr. Foote visited with officers of Gulf States Utilities Company, whose main office is located in Beaumont.

In the evening, a banquet was held at the Beaumont Country Club, attended by engineers, their wives, and guests of the Beaumont Section. Mr. Foote spoke on his trip to Russia in 1957. He showed color slides illustrating engineering developments and social life inside Russia.

Notice to Sections

In observance of Armed Forces Day, which will be held this year on May 21, the Armed Forces Day Committee has extended to the AIEE and its membership in eight States—Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, and New Jersey—an invitation to hear guest speakers representing the Armed Forces. This invitation applies particularly during the period May 14-22, 1960.

The 1960 Armed Forces Day Program will again keynote the "Power for Peace" theme. The Active and Reserve Forces of the United States, in co-operation with national, state, and local leaders in civic affairs, will emphasize to the world that the "Power for Peace" mission of the Armed Forces is not merely a slogan but a firm resolve. The purpose of the Speakers' Program is to increase the public understanding of the role of the Armed Forces.

Military speakers may be obtained by telephoning or writing to the nearest Armed Forces Installation or to the Area IV Armed Forces Day Committee at Mitchel Air Force Base, N. Y.

The invitation to the AIEE and its membership was extended on behalf of the President of the United States by U. S. Air Force Col. J. W. Robie, executive secretary, Area IV Armed Forces Day Committee.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grade, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

Hotels and Motels Listed for 1960 Summer General Meeting

The 1960 Summer General Meeting will be held in Atlantic City, N.J., June 19-24. The Chalfonte-Haddon Hall Hotels will be meeting headquarters and the AIEE Philadelphia Section will act as hosts for the meeting.

In addition to well-rounded technical sessions, there will be a full list of interesting social and sports events for everyone, including many activities of special interest to the ladies.

The Chalfonte-Haddon Hall Hotels will act as housing bureau for the meeting and will handle all room requests in the order of their receipt. Requests for room reservations for all the hotels and motels listed should be sent to Chalfonte-Haddon Hall.

Haddon Hall
Single, One Person ..... $11.50 to $20.00
Double, Two Persons ..... $13.00 to $50.00

Chalfonte (across street)
Single, One Person ..... $7.00 to $16.00
Double, Two Persons ..... $10.00 to $22.00

For each additional person in a double room, the rate will be $4 on the European plan and $12 on the American plan. The charge on the American plan will be $8 per day per person. A rebate will be given when an American plan guest misses a regular hotel meal to attend general meeting meal functions in Chalfonte-Haddon Hall. All persons in the same room must be on the same plan.

Aristocrat Motel (Pennsylvania Ave.)
Double ..... $12.00 to $18.00

Carolina Crest Motel (North Carolina Ave.)
Double ..... $12.00 to $14.00

Colton Manor Hotel (Pennsylvania Ave.)
Double (twin beds) ..... $10.00 to $18.00
Two Rooms, One Bath, Three Persons $15.00
Two Rooms, One Bath, Four Persons $18.00

Coronet Motel (North Carolina Ave.)
Double ..... $12.00 to $18.00
Single ..... $10.00 to $12.00

Sahara Motel (Pennsylvania Ave.)
Double ..... $16.00 to $22.00

Seaside Hotel and Motel (Pennsylvania Ave. and boardwalk)
Single, One Person $12.00
Double, Twin Beds ..... $12.00 to $20.00

Tides Motel (North Carolina Ave.)
Double ..... $12.00 to $14.00

Technical Conference on Paper and Pulp Scheduled

The AIEE Paper and Pulp Industry Subcommittee will sponsor a technical conference on electrical engineering as applied to that industry on April 21-22, 1960, at the University of Florida, Gainesville, Fla.

The conference headquarters will be at the Holiday Inn Motel. Other convenient motels include the Bambi, Casaloma Lodge, and Florida Motor Court.

AIEE PERSONALITIES

Nominated To Serve as Institute President, 1960-61

Clarence Hugo Linder (M '54, F '57), vice-president and group executive—Electric Utility Group of the General Electric Company, New York, N. Y., has been nominated for the office of president of the AIEE. He was born January 18, 1903, in Omega, Wis. and educated at the University of Texas from which he received the B.S. and M.S. degrees in electrical engineering in 1924 and 1927, respectively. His association with General Electric began in 1924. Mr. Linder has managed both engineering and manufacturing operations related to a wide variety of General Electric products, ranging from heavy apparatus to consumer goods. In 1950, he became general manager of the company's activities in the large appliance field. He was elected a vice-president in 1953. During 1953-59, Mr. Linder was vice-president—engineering and a member of General Electric's Executive Office. Early in 1960, he became vice-president and group executive—Electric Utility Group. In this office, he is responsible for those General Electric business components whose prime purpose is to serve the electric utility industry. Mr. Linder is a member of the American Society of Mechanical Engineers, the United Engineering Trustees Inc., the Engineers Joint Council, the National Society of Professional Engineers, and the American Association for the Advancement of Science. He is a permanent member of the U. S. National Committee of the International Conference on Large Electric Systems. Mr. Linder is a term member of the Massachusetts Institute of Technology Corporation. He was twice the recipient of the honorary degree of doctor of engineering, in 1955 from the Worcester Polytechnic Institute and in 1956 from the Clarkson College of Technology. Mr. Linder is a licensed professional engineer of the state of New York. He was treasurer of the AIEE in 1958-60 and a director during 1956-58. He has served on the following AIEE Committees: Finance (1956-58, chairman 1957-58); Planning and Coordination (1956-59); Executive (1957-60); U. S. National Committee, Council of the International Electrotechnical Commission (1957-58); and the United Engineering Trustees (1957-58).

Nominated To Serve as Institute Vice-Presidents

Clair Eugene Gaylord (AM '26, M '48), plant engineer of the New York Telephone Company, Buffalo, N. Y., has been nominated for the office of vice-president for AIEE District 1. Mr. Gaylord was born April 26, 1901, in North Collins, N. Y. In 1925, he received the bachelor's degree in electrical engineering from Ohio State University. An employee of the New York Telephone Company before entering college, he returned to that company in Buffalo as assistant engineer after graduation. Later, as a plant engineer he was responsible for the design and planning of engineering projects covering trunk and exchange aerials, underground and submarine cables, pole lines, and underground conduit in the metropolitan and urban areas of Western New York. These were engineered to provide for plant extension, additions, central office cutovers, and rehabilitation. He has acted as consulting engineer for independent telephone companies when they requested assistance from the New York Telephone Company. He has taught in a company-operated transmission school for telephone engineers. He was a member of the 2-man electronic research team which designed a special communication-type facility used in connection with power transmission line operation. He is now responsible for supervising the engineering of all outside plant facilities for the southern portion of the city of Buffalo and adjoining metropolitan districts, an area containing 42,000 telephones. Mr. Gaylord is a licensed professional engineer in the state of New York and a member of the New York State Society and the National Society of Professional Engineers.

Robert T. Weil, Jr. (AM '32, M '44), professor and head of the Department of Electrical Engineering, Manhattan College, New York, N. Y., has been nominated for the office of vice-president for AIEE District 3. He was born July 29, 1908, in Brooklyn, N. Y. In 1930, he received the electrical engineering degree from the Polytechnic Institute of Brooklyn, and in 1935, the M.S. degree in electrical engineering from Columbia University. After undergraduate school, he was employed by the General Electric Company on the test course in Lynn, Mass., and Schenectady, N. Y. During the Summers of 1952-54, he returned to General Electric at Pittsfield for special assignments in the underwater engineering department. Mr. Weil was appointed an instructor at Manhattan College in 1932, and a full professor in 1945. He did graduate work at the Polytechnic Institute during 1938-43. In 1945, he was appointed head of the Department of Electrical Engineering at Manhattan College. During World War II, he served as an adjunct professor of electrical engineering at New York University. He is coauthor, with the late Dr. Michael Liwschitz-Garik, of the text book "D-C and A-C Machines," published in 1952. Mr. Weil is a registered professional engineer in New York and a member of the Institute of Radio Engineers, the New York State Society of Professional Engineers, Tau Beta Pi, Eta Kappa Nu, and Sigma Xi. He is a member of the American Society for Engineering Education of which he was chairman of the Middle Atlantic Section in 1949. He was chairman of the New York Section, AIEE, in 1955-56 and has been a member of the Section Advisory Committee since then. He is now secretary of AIEE District 3. He has served on the AIEE Student Branches Committee (1950-60); the Joint Subcommittee of the Institute of Radio Engineers Education Committee and the AIEE Committee on Student Branches (chairman 1952-53); and as AIEE representative to the Library Board of the United Engineering Trustees, Inc. (1955-58).

Fred Walton Bush (AM '36, M '43), assistant to the vice-president, Power Equipment Division, of the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been nominated for the office of vice-president for AIEE District 5. Mr. Bush was born in Augusta, Ga., on November 27, 1905, and received the B.S. degree in electrical engineering in 1928 from the Georgia School of Technology. Immediately upon graduation, he entered the Allis-Chalmers graduate training pro-

C. H. Linder

C. E. Gaylord

Albert Gaida Photo

R. T. Weil, Jr.

F. W. Bush

Don' Photo

S. C. Wright

General Electric Photo

H. A. Carlberg

A. W. Rauth

Walter Criley

gram in Milwaukee. After completion of training, he entered the transformer engineering department, where he was engaged in early development work on impulse testing of large high-voltage power transformers. He also contributed to the original development of the step-type feeder voltage regulator for which he holds patents. After serving as engineer-in-charge of the High Voltage Laboratory, he became engineer-in-charge of transformer and regulator sales. He later became assistant manager of the electrical department before the formation of the power department, of which he was also assistant manager. At Georgia Tech, he was vice-chairman of the AIEE Student Branch. Since then, he has served AIEE as secretary and treasurer of the Milwaukee Section, chairman of the Milwaukee Section, and secretary and treasurer of the AIEE Great Lakes District 5. Mr. Bush is a member of Tau Beta Pi and Phi Kappa Phi. He has been active in the National Electical Manufacturers Association, is a member of its Codes and Standards, Product Scopes, and Utilization Voltages and Circuits Committees, and was chairman of its Transformer Section and Feeder Voltage Regulator Section. He has been active in power survey work and is presently a representative on the Power Survey Committee of the Edison Electric Institute. He is a member of the American Standards Association, and an alternate member of the Electrical Standards Board, Standards Council, and the U. S. National Committee of the International Electrotechnical Commission. Mr. Bush is a member of the Engineer's Society of Milwaukee. He has served on the following AIEE Committees: Management (1947-52); Fortescue Fellowship (1949-52); and Educational Publications (1957-58).

Sim C. Wright (AM '41, M '52), outside plant engineer in the Oklahoma area for the Southwestern Bell Telephone Company, has been nominated for the office of vice-president of AIEE District 7. He was born November 16, 1906, in Elida, N. Mex. In 1929, he received the B.S. degree in electrical engineering from the University of Oklahoma. Upon graduation, he joined the Southwestern Bell Telephone Company in Oklahoma City. His experience with the company has been in Oklahoma City and Tulsa, Okla., as exchange engineer, district engineer, senior engineer, and outside plant engineer. Special assignments have included service as a consultant to the U. S. Signal Corps on construction and maintenance of communication systems at the Tulsa Aircraft Assembly Plant and chairman of the Oklahoma Intertoll Dialing Committee. In his present position of outside plant engineer, he is responsible for the engineering and design of the telephone plant to serve all types of communication requirements which are provided by the Southwestern Bell Telephone Company throughout the state of Oklahoma. Mr. Wright is a member of the National Society of Professional Engineers and the Oklahoma Society of Professional Engineers and is presently on the board of directors of both organizations as national director from Oklahoma. He is a past president of the Engineering Club of Oklahoma City and a member of Eta Kappa Nu. He served on the AIEE Publication Committee (1952-54) and Membership Committee (1955-56).

Henry Arthur Carlberg (AM '37, M '50), plant engineering manager, Hanford Works, General Electric Company, Richland, Wash., has been nominated for the office of vice-president of AIEE District 9. He was born March 11, 1913, in Rockford, Ill. In 1936, he received the B.S. degree in electrical engineering from the University of Wisconsin. During 1936-39, he was an electrical engineer for the Wisconsin Public Service Corporation. Mr. Carlberg taught engineering economics at the University of Wisconsin in 1939-40. He returned to the Wisconsin Public Service Corporation in 1940. The following year, he was employed by the Harza Engineering Company as an electrical engineer. In 1942-44, he worked for the U. S. Corps of Engineers, New York District and Manhattan District. He was responsible for transmission system design and studies, and power contracts. Mr. Carlberg maintained and operated transmission, distribution, and communication systems, plus process electric equipment for I. E. DuPont & Company in 1944-46. He joined the General Electric Company in 1946. Mr. Carlberg is a registered professional engineer of the state of Washington. He is a past chairman of the Richland Section, AIEE, and has served on the AIEE Registration of Engineers Committee (1951-57) and Nucleonics Committee (1957-60).

Adolph William Rauth (AM '28, F '48), general meter and laboratory superintendent of the Consumers Power Company, Jackson, Mich., has been nominated for the office of vice-president for AIEE District 11. He was born February 3, 1898, in Warrick County, Ind., and graduated from Purdue University in 1923 with the B.S. degree and in 1929 with the electrical engineering degree. In 1923, he went to Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., as a student engineer. He spent 12 months in their shop and test course. In 1924, he was assigned to the switchboard engineering department of the Westinghouse Company. During 1925-26, he taught trigonometry, electrical measurements, d-c machinery, electrical design, and electrical laboratory work at Rose Polytechnic Institute, Terre Haute, Ind. In 1926-30, he worked with predecessor companies of the Commonwealth and Southern Corporation in Jackson, Mich. Mr. Rauth was a member of the Consumers Power Company engineering department in 1930-36. His work consisted mainly of short-circuit calculations, relay, and oil circuit breaker application. He was advanced to his present position as superintendent of Consumers Power Company's Electrical Laboratory in 1936. Mr. Rauth is a registered professional engineer of the state of Michigan. He is presently chairman of the Meter and Service Committee of the Association of Edison Illuminating Companies and is a past chairman of the Metering Subcommittee of the American Gas Association. He is chairman of a number of task committees to rewrite metermen's handbooks and standards for both the electric and gas metering art. He is the author of patents on the automatic testing of electric and gas meters. He is active in the International Association of Electrical Inspectors and is a member of the Indiana Academy of Science. Mr. Rauth is a past chairman of the Michigan Section, AIEE. He is now vice-president AIEE District 11 (1959-60). He has served on the AIEE Technical Program Committee (1944-45) and Indicating and Integrating Instruments Committee (1957-60).

Walter Criley (AM '38, M '46), professor of electrical engineering at Vanderbilt University, Nashville, Tenn., has been nominated for the office of vice-president of AIEE District 13. Born May 18, 1900, in Philadelphia, Pa., he was educated at the University of Pennsylvania from which he received the B.S. degree in 1921 and the electrical engineering degree in

1940. In the Summer of 1919, he worked as a tracer in the drafting department of the Philadelphia Electric Company. The following Summer, he took the junior test course of the General Electric Company, Lynn, Mass. During 1921-22, he was transmission tester for the American Telephone and Telegraph Company in New York, N. Y. In 1922-23, he was an instructor in electricity at the Georgia Institute of Technology, Atlanta, Ga. In the Summer of 1923, he took the course for engineering teachers given by the Westinghouse Company in East Pittsburgh, Pa. During 1923-25, he was an instructor in electricity at the University of Pennsylvania. Mr. Criley was employed by the Pennslyvania Power and Light Company, Allentown, Pa., as cost engineer for street railway properties in 1925-30. For the next 7 years, he taught electricity at the Rochester Institute of Technology. In 1937-47, Mr. Criley was an engineer for the Rochester Telephone Corporation, Rochester, N. Y. He became an associate professor of electrical engineering at Vanderbilt University in 1947 and was promoted to his present position of professor in 1955. He is a registered professional engineer of the state of Tennessee and a member of the Tennessee Chapter of the National Society of Professional Engineers. Mr. Criley is a member of the American Society for Engineering Education. He is a past chairman of the AIEE Rochester Section (1943-44), and Nashville Section (1951-52). He has served on the following AIEE Committees: Student Branches (1953-59); Sections (1953-58); and Membership, District 13 representative (1959-60).

Paul G. Wallace (AM '40, M '47), assistant chief engineer of the Texas Power & Light Company, Dallas, Texas, has been nominated for the office of vice-president of AIEE District 15. Born January 15, 1903, in Omaha, Texas, he attended Burleson College and Texas Agricultural and Mechanical College. In 1924, he joined the Texas Power and Light Company, working in the engineering and operating departments in various capacities until 1939, when he was appointed head of the Electrical Design Division of the company. This work consisted of supervising the planning and designing for rural and urban distribution, transmission systems, substation and generating stations. He became chief electrical engineer in 1951 and assistant chief engineer in 1952. He is a registered professional engineer of the state of Texas, a member of the Texas Society of Professional Engineers. He is a past chairman of the North Texas Section, AIEE (1949). He has served as an AIEE director (1955-59) and has been a member of the following AIEE Committees: Registration of Engineers (1949-51); Transmission and Distribution (1950-60); Edison Medal (1953-58); Constitution and Bylaws (1955-57); Safety (1956-57); and Publications Department (1959-60).

Nominated To Serve as Institute Directors

Robert B. Gear (AM '30, F '55), director of purchases of the Commonwealth Edison Company, Chicago, Ill., has been nominated as a director of the AIEE. He was born October 16, 1904, in Chicago, Ill., and was educated at Cornell University from which he received the B.S. degree in electrical engineering in 1928. After graduation, he took the Commonwealth Edison student training course and was thereafter assigned to the distribution engineering department on 4-kv and industrial service work. In 1936, he became field engineer on generating station engineering, supervising work in large distributing stations, 66-kv terminals, and generating station switchhouses. During 1941-45, he served with the U. S. Army Corps of Engineers on the staffs of the Second Army, the Allied Force Headquarters, the Chief of Engineers, and the Army Service Forces Headquarters, and had attained the rank of colonel in 1944. Returning to the Edison Company, he progressed to section engineer of the station engineering department, in charge of generating station electrical design for certain units. On establishment of the Nuclear Power Study Group in 1951, he became the technical director and later manager. After a short time as staff assistant to the executive vice-president, Mr. Gear was transferred in 1953 to purchasing activities, became director of purchases in 1954, with responsibilities for buying, traffic, stores, and inventory control functions. Mr. Gear is a registered professional engineer of the state of Illinois and has served as a director of the Illinois Engineering Council (1952-55). He is a past chairman of the Chicago Section, AIEE (1955-56), and vice-president of the AIEE Great Lakes District 5 (1958-60). He has served on the AIEE Marston Medal Board of Award Committee (1956-60).

Charles Trabue Hatcher (M '37, F '54), division engineer, Consolidated Edison Company of New York, Inc., New York, N. Y., has been nominated as a director of the AIEE. Born October 4, 1897, in Chester, Va., Mr. Hatcher was graduated in 1920 from the University of Virginia with the electrical engineering degree and then became associated with the Western Electric Company in New York. He was employed in October 1922 by the United Electric Light and Power Company with the title of assistant engineer. He has since been continuously employed by this company and its successor companies, now the Consolidated Edison Company of New York. Mr. Hatcher was engaged in planning work, with particular emphasis on scale installations, during 1922-29. In 1933, he became division engineer of the Cable Division of the United Electric Light and Power Company. From that time, he has been in responsible charge of cable engineering and cable engineering administration in an ever-expanding system which serves all five boroughs of the city of New York and Westchester County. He is responsible for all engineering in respect to cables and associated accessories for the systems of Consolidated Edison and has conducted pioneer work in many phases of cable engineering. Mr. Hatcher has served on technical committees of the American Society for Testing Materials, the American Standards Association, the Association of Edison Illuminating Companies, and the International Conference on Large Electric Systems. Mr. Hatcher is a registered professional engineer of the state of New York. He has served on the following AIEE Committees: Insulated Conductors (1947-53, chairman 1951-53); liaison representative on Standards (1951-53); Power Division (1951-59, chairman 1955-57); Award of Institute Prizes (1953-55); Technical Operations (1955-60, chairman 1959-60); and Joint Division Committee on Automation and Data Processing (1956-57).

Cullen Thomas Pearce (AM '36, F '49), Atlantic Region engineering and service manager, Westinghouse Electric Corporation, Philadelphia, Pa., has been nominated as a director of the AIEE. He was born September 25, 1901, in Wilkerson Valley, Texas. In 1923, he received the B.S. degree in electrical engineering

P. G. Wallace

R. B. Gear

C. T. Hatcher

Fabian Bachrach Photo

C. T. Pearce

from the University of New Mexico, and in 1935, the M.S. degree in electrical engineering from the University of Pittsburgh. He entered the employ of the Westinghouse Electric Corporation in 1923 in the company's graduate student training course in East Pittsburgh, Pa. Upon completion of this course, he became associated with the design of large direct-current rotating apparatus and was employed in this field until 1927. During 1927-35, he was identified with the application of marine and industrial equipment manufactured by Westinghouse. In 1935, he was transferred to the company's Philadelphia Office where he became engaged in the engineering selection and application of equipment used by industries in the Middle Atlantic area. In 1938, he was appointed Atlantic Region engineering manager of Westinghouse, and in 1941, was made Atlantic Region engineering and service manager, the position he now holds. He is responsible for the engineering work associated with the application of electrical and mechanical apparatus manufactured by Westinghouse and used by industries located in the Middle Atlantic States, together with the servicing, installation, and repair of this apparatus. He served as president of the Engineers' Club of Philadelphia (1954-55). Mr. Pearce holds a professional engineer's license in the state of Pennsylvania and is the 1959-60 vice-president of the Philadelphia Chapter of the Pennsylvania Society of Professional Engineers. He is a member of the American Society of Mechanical Engineers, the Institute of Radio Engineers, the American Society for Engineering Education, the American Society of Naval Engineers, and Eta Kappa Nu. He served as vice-president of AIEE District 2 (1955-57), and has served on the following AIEE Committees: Membership (1946-49); Rotating Machinery (1952-53); Transfers (1954-55); and Administration (1957-58, chairman 1960).

Nominated To Serve as Institute Treasurer

William Russell Clark (AM '37, M '50), manager of the Product Engineering Division, Leeds and Northrup Company, Philadelphia, Pa., has been nominated for the office of treasurer of the AIEE. He was born November 28, 1907, in Trainer, Pa., and was educated at the Moore School of the University of Pennsylvania from which he received the B.S. degree in 1929, the M.S. degree in 1932, and the Sc.D. in 1938, all in electrical engineering. In 1929, he joined the Leeds and Northrup Company, Philadelphia, Pa., as a research assistant. In June 1932, he became associated with the Franklin Institute Museum staff, where he took charge of the Electricity and Magnetism Section of the physics department. He returned to Leeds and Northrup in 1934 as an electrical research engineer. In 1945, Dr. Clark became supervisory research technologist of the Electrical Division of the research department, and in 1952, was appointed chief of the Electrical Division of the research department. He was appointed chief of the Electromechanical Division of the research and development department in 1955 and was appointed manager of the Product Engineering Division, in 1956. He is a senior member of the Institute of Radio Engineers, a member of the Instrument Society of America and the Engineers Club of Philadelphia. He served for several years on the Panel on Test Equipment of the Research and Development Board of the U. S. Military Establishment. Dr. Clark is an AIEE director (1956-61) and has served on the following AIEE Committees: Electronics (1945-55, 1958-60); Instruments and Measurements (1947-55, chairman 1949-51); Technical Program (1949-50); Standards (1949-50); Science and Electronics (Co-ordinating) Division (1949-57, chairman 1952-54); Technical Operations (1952-60, chairman 1956-57); Instrumentation Division (1956-57); Recording and Controlling Instruments (1956-57); Board of Directors (1956-61); Planning and Co-ordination (1956-60); Constitution and Bylaws (1957-58); Recognition Awards (1957-58); Finance Committee (chairman 1958-60); and Executive Committee (1959-60).

W. R. Clark

W. F. Bailey (AM '34) has been appointed associate director of research, Hazeltine Research Corporation, Little Neck, N. Y. He had been chief engineer of the corporation's Research Division.

The board of directors of the Institute of Radio Engineers (IRE) have named the following officers for 1960: **W. R. G. Baker** (AM '19, F '47), president of Syracuse University Research Corporation, Syracuse, N. Y., as treasurer: **Haraden Pratt** (AM '15, F '37), engineering consultant, as secretary; **Ferdinand Hamburger, Jr.** (AM '26, F '48), professor and chairman of the department of electrical engineering, Johns Hopkins University, Baltimore, Md., as editor. Mr. Hamburger succeeds **J. D. Ryder** (AM '40, F '51), dean of engineering, Michigan State University, East Lansing, Mich. Mr. Baker and Mr. Pratt were re-elected to office. All three officers also serve as directors. Elected as directors were: **L. V. Berkner** (AM '29, F '47), president of Associated Universities, Inc., New York, N. Y.; and **A. N. Goldsmith** (M '15, F '20, Member for Life), consulting engineer, New York, N. Y., and editor emeritus of the IRE. Mr. Baker served on the following AIEE Committees: Electronics (1945-57, chairman 1945-47) and Communication and Science Co-ordinating (chairman 1947-48). Mr. Pratt was a member of the AIEE Communication Committee (1937-47, chairman 1941-43). Mr. Hamburger serves on the Electronic and High Frequency Instruments Committee (1956-60, chairman 1956-58). Mr. Ryder has served on the following AIEE Committees: Education (1949-57, chairman 1952-54); Research (1955-60); and Edison Medal (1955-60).

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P. A. Borden (AM '13, F '44), associate professor of electrical engineering at the University of Dayton, Ohio, is coauthor of a book entitled "Telemetering Systems." He serves on the AIEE Instrumentation Division Committee (1958-60).

E. L. Cahlick (AFFIL. '54) has been appointed manager of the Dallas Customer Service Center of the Federal Pacific Electric Company, Newark, N. J. He was formerly plant manager at the Federal Pacific Cleveland Customer Service Center.

E. E. Campbell (AM '37), formerly area engineer in the Front Royal, Va., plant of American Viscose Corporation, has been named plant engineer.

R. N. Carson (AM '52) has been appointed project engineer in the Inet engineering department of Leach Corporation, Compton, Calif.

Frank Collamore (AM '49) has been appointed chief development engineer for an intensified Inet Division power equipment development program of Leach Corporation. Mr. Collamore joined Leach in 1954.

C. E. Dean (AM '23, F '55), consulting engineer, and **R. K. Hellmann** (AM '37, M '45), vice-president and director, Hazeltine Research Corporation, are among the five Long Islanders who were honored as Fellows of the Institute of Radio Engineers (IRE). The awards were presented at the annual banquet of the IRE's Long Island Section in March. Dr. Dean has served on the following AIEE Committees: Broadcasting (1949-60, chairman 1952-54); Communication Division (1952-60); Special Publications (1957-60, chairman 1957-58); and Technical Operations (1959-60). Dr. Hellman has been a member of the following AIEE Committees: Communication Theory (1955-60, chairman 1957-59); Electronic and High Frequency Instruments (1956-60); and Communication Division (1957-60).

Included among the leading engineering figures named by the National Society of Professional Engineers to act as sponsors for the 1960 National Engineers' Week held February 21-27, 1960, were the following: **A. B. DuMont** (F '43), chairman of the board, Allen B. DuMont Laboratories, Inc.; **C. H. Linder** (M '54, F '57), vice-president, General Electric Company; and **Philip Sporn** (AM '20, F '30, Member for Life), president, American Elec-

tric Power Company. Mr. Linder is the AIEE treasurer (1958-60), former director (1956-58), and has served on the following AIEE Committees: Finance (1956-58, chairman 1957-58); and Executive (1957-60). Mr. Sporn was the Edison Medalist for 1945 and served on the Transmission and Distribution Committee (1927-47, chairman 1941-43).

M. A. Edwards (M '40, F '47), engineering manager of the General Electric Company X-ray department in Milwaukee, Wis., since 1952, has been appointed manager of the new "Advanced Product Planning Operation" to study opportunities for developing new and unique products for use in electronic equipment. Headquarters for this new operation will be in Schenectady, N. Y. Dr. Edwards has served on the AIEE Nucleonic and Radiation Instrumentation Committee (1958-60).

K. R. Geiser (AM '38, M '53), former manager of engineering in the computer department, General Electric Company has been named manager of the department's newly organized business-planning operation. **R. R. Johnson** (AM '53), former manager of the department's Computer Laboratory at Palo Alto, Calif., was named manager of engineering. Dr. Johnson serves on the AIEE Computing Devices Committee (1959-60).

R. J. Gilson (AM '50) has been appointed director of systems management in Stromberg-Carlson's Electronics Division, Rochester, N. Y. Stromberg-Carlson is a division of General Dynamics Corporation. Mr. Gilson came to Stromberg-Carlson from the Hoffman Laboratories Division of Hoffman Electronics Corporation in Los Angeles, Calif., where he was program director for the "Tall Tom" airborne reconnaissance system.

G. A. Goddard (AM '47) has recently retired from the General Electric Company in Baltimore, Md., where he had the position of manager-marketing of the insulator department.

N. L. Harvey (AM '35, M '50), engineering vice-president, Electronics Division, Columbia Broadcasting System, Inc. (CBS), Danvers, Mass., recently described some of the firm's advanced developments in microcircuitry to a group of Burroughs Corporation engineering executives at CBS Electronics, Danvers.

E. W. Hassel (AM '47) has been named manager of tone-signalling and filter design engineering, General Electric's communication products department, Lynchburg, Va. Mr. Hassel has been with General Electric since 1951.

M. D. Hooven (AM '24, F '44) has been promoted to consulting engineer in the electrical engineering department of Public Service Electric and Gas Company. The position is a newly created one. Mr. Hooven was formerly electrical engineer in the department. He is a former AIEE president (1955-56).

Daystrom, Inc., has established a Technical Advisory Committee of university scientists, which includes: **Dr. T. F. Jones, Jr.** (M '58), head of the School of Engineering, Purdue University, Lafayette, Ind., who has a broad interest in electronic systems; **Dr. J. G. Truxal** (AM '51, M '54), head of the department of electrical engineering, Polytechnic Institute of Brooklyn, an authority on automatic control systems; and **Dr. H. H. Woodson** (AM '53), associate professor of the department of electrical engineering, Massachusetts Institute of Technology, who is an expert on electromechanical energy conversion. Dr. Truxal serves on the following AIEE Committees: Feedback Control Systems (1956-60, chairman 1959-60); Automation and Data Processing (1958-60); Recognition Awards (1959-60); and Industry Division (1959-60).

P. W. Joy (AM '55) of Grand Island, N. Y., has moved up from assistant manager to manager of the technical branch in the Curtis Machine Division of the Carborundum Company.

D. Y. Keim (AM '37) has been appointed director of engineering in Stromberg-Carlson's Electronics Division. He will be responsible for the administration of design and development engineering work in the division. Mr. Keim joined Stromberg-Carlson, a division of General Dynamics Corporation, in 1959 as chief engineer of military products in the Electronics Division.

C. F. Kober (AM '43) has been appointed authorized sales representative in Michigan for National Electric Welding Machines Company, Bay City, Mich. Mr. Kober formerly was associated with National in its engineering, experimental, and testing departments. More recently he had been active in Michigan as an industrial sales and application engineer.

R. C. Langford (M '55) has been appointed director of engineering of the Newark Operations of Weston Instruments Division of Daystrom, Inc. The plant is a unit in Daytrom's Industrial Products Group. Dr. Langford was formerly chief engineer for Research and Development at the Newark Operation. In his new position, he succeeds **F. X. Lamb** (AM '36, F '58), formerly the Newark plant's vice-president of engineering. Mr. Lamb was named engineering consultant to the vice-president of operations at Newark. Dr. Langford has served on the AIEE Indicating and Integrating Instruments Committee (1957-60).

E. E. Linden (AM '47, M '54), formerly engineer with the Narragansett Electric Company of Providence, R. I., has been promoted to executive assistant in the office of the president of the company. Mr. Linden has served on the following AIEE Committees: Membership (1957-60); Domestic and Commercial Applications (1958-60), and Sections (1958-60).

H. T. Mooers (AM '48, M '56), formerly the staff assistant to the sales manager of the Minneapolis Honeywell Semiconductor Division, has been named manager of applied research for the Monarch Electronics Company Division of the American-Monarch Corporation, Minneapolis, Minn.

F. A. Morris (M '56) has been appointed an acting director of engineering in the Special Products Division of Stromberg-Carlson, a division of General Dynamics Corporation, Rochester, N. Y. Since 1945, he had directed telecommunications research. He serves on the following AIEE Committees: Communication Switching Systems (1956-60), Research (1959-60), Communication Theory (1959-60), and Data Communication (1959-60).

I. L. Newberg (AM '54) has become a member of the technical staff at Ramo-Wooldridge, a division of Thompson Ramo Wooldridge Inc., assigned to the Reconnaissance Systems Division. Also newly associated with this division is **R. J. Black** (AM '51).

G. A. Olive (AM '50) has been appointed a staff engineer, Engineering Plans and Services, Industrial Electronic Products, Radio Corporation of America, New York, N. Y. Prior to his promotion, Mr. Olive was a member of the technical staff, David Sarnoff Research Center, Princeton, N. J.

V. C. Rideout (AM '47, M '57), professor of electrical engineering at the University of Wisconsin, has been elected a fellow of the Institute of Radio Engineers.

R. B. Steinmetz (AM '26, M '48), formerly executive vice-president of the Anaconda Wire and Cable Company, has become president of the company. **D. E. Allen** (AM '23, Member for Life), vice-president—sales, has been elected to the position of executive vice-president as successor to Mr. Steinmetz. **H. V. Van Valkenburg** (AM '45), previously general sales manager, has been elevated to vice-president and general sales manager.

G. J. Taylor (M '44, F '58), vice-president of Eastern Operations, Day-Brite Lighting, Inc., has been transferred to the home office in St. Louis, Mo., as vice-president in charge of research, development, and marketing.

O. L. Taylor (M '57) has been appointed engineering manager of Westinghouse Electric Corporation's new Portable Appliance Division, located at the company's Mansfield, Ohio, plant. Mr. Taylor had been at Bridgeport, Conn., as engineering manager of Bryant Electric Company, a subsidiary of Westinghouse.

L. H. Walke (AM '55) has been appointed director of utility sales for Federal Pacific Electric Company, with headquarters in Newark, N. J. Mr. Walke came to Federal Pacific from the Allis-Chalmers Manufacturing Company.

Support the New United Engineering Center

E. J. Warner (AM '51, M '57), president, has been appointed to the board of directors of Spectra Electronics Corporation, Mount Vernon, N. Y.

OBITUARIES

Kurt Anderson (AM '41), sales engineer for Koontz-Wagner Electric Company, Inc., South Bend, Ind., died recently. He was born July 29, 1901, in Sweden, and attended the University of Orebro in Sweden from which he graduated in June 1922 with a degree in electrical engineering. He was employed in the United States by the Indiana and Michigan Electric Company as a distribution engineer for the period 1925-42. About 15 years of this service was in the St. Joseph–Benton Harbor, Mich., area, and the last 2 years in South Bend. In 1942-45, he was supervisor of the electrical department at Bendix Products Division, South Bend. In 1945, he joined Koontz-Wagner as distribution manager.

A. H. S. Cantlin (AM '17, Member for Life), a member of the Lehigh Valley Section, AIEE, died recently. He was born June 22, 1878, and was a graduate of the University of Pennsylvania with the B.S. degree in electrical engineering. He was assistant engineer for the St. Louis Transit Company, St. Louis, Mo., and held the same position at the Union Electric Light Company in Missouri. He was manager and engineer in the St. Louis office of the Electric Storage Battery Company. During 1908-16, he was manager and vice-president of the Lehigh Valley Light and Power Company and consulting engineer of the Lehigh Valley Transit Company.

Robert David Charlton (AM '45, M '51), an electrical engineer with the General Electric Company, Erie, Pa., died recently at the age of 38. He was born August 28, 1921, in Fort Sam Houston, Texas. During 1938-40, he attended the University of Hawaii and, in 1940-43, the University of Texas from which he graduated with the B.S. degree in electrical engineering. In 1948, he graduated from the advanced engineering program of the General Electric Company and served 2 years as instructor and supervisor at Schenectady, N. Y. Mr. Charlton had served as chairman of the Erie Section, AIEE, and was an honorary member of Tau Beta Pi and Eta Kappa Upsilon.

George J. Christ (AM '46, M '54), supervising engineer, Bronx Engineering Division, New York Telephone Company, died recently. He was born September 18, 1908, in Brooklyn, N. Y. In 1929, he received the electrical engineering degree from Brooklyn Polytechnic Institute. During 1929-30, he was an equipment engineer for the New York Telephone Company. He was transmission engineer for the company in 1930-38, engineer in 1938-39, and staff engineer in 1939-43. He was a member of the technical staff of Bell Laboratories, New York, in 1943-45, and in 1945 became supervising engineer with the New York Telephone Company. Mr. Christ was an instructor in radio fundamentals at Manhattan College in 1942-43. The following year, he became instructor in electrical engineering at New York University.

Everett E. George (AM '20, M '29, F '36, Member for Life), a member of the electrical consulting department of Ebasco Services, Inc., Little Rock, Ark., until his retirement on November 30, 1959, died recently. He was born November 27, 1892, in Madison, Ind. In 1913, he received the B.S. degree in electrical engineering from Purdue University. Mr. George was employed in 1913 as a test foreman for the American Rotary Valve Company, Anderson, Ind. In 1914, he became assistant efficiency engineer for Barney & Smith Car Company, Dayton, Ohio; in 1915, production engineer with the National Steel Car Company, Hamilton County; in 1916-17, plant engineer with the Lodge & Shipley Machine Tool Company, Cincinnati, Ohio. He went to Nitro, W. Va., in 1918 to work as field supervisor with the Hercules Powder Company, and in 1919, he became valuation engineer for A. L. Drum & Company, Chicago, Ill. He held the same position in 1920 for H. P. Gillette & Company, Chicago. During 1921-22, he was a valuation engineer for R. M. Feustel & Company, Fort Wayne, Ind. In 1923, he took the position of relay engineer for the Tennessee Electric Power Company, Chattanooga, Tenn., was advanced in 1925 to the position of superintendent of electrical operation, and in 1928, to superintendent of system operation. He served on the following AIEE Committees: Protective Devices (1928-31, 1935-37); Communication (1936-47); Automatic Stations (1942-47); and System Engineering (1947-56).

Charles Addison Maynard (AM '39, M '55), vice-president and secretary, Indiana General Corporation, died recently. He was born May 4, 1901, in Kansas City, Mo., and attended the University of Kansas in 1919-23 and Taylor University in 1924-25. During 1920-23, he was a draftsman for Western Electric Company. Mr. Maynard was employed by the Indiana Steel Products Company in 1932 as a design engineer, advanced to chief engineer in 1937, and to director of research and engineering in 1947. In 1952-58, he was vice-president, research and engineering, of Indiana Steel Products Division. He was a senior member of the Institute of Radio Engineers and a member of the Instrument Society of America, the American Society for Testing Materials, and the Electronic Industries Association. He held patents for the following: magnetic separator, permeameter, permanent magnetic generator, telephone receiver, and measuring liquid dispenser. He was a member of the AIEE Solid-State Devices Committee (1956-57).

James Wilson McRae (AM '37, M '50), a vice-president of the American Telephone and Telegraph Company, New York, N. Y., and co-ordinator of defense activities for the Bell Telephone System, died recently at the age of 49. He was born October 25, 1910, in Vancouver, B. C., Canada. He was educated at the University of British Columbia from which he received the B.S. degree in electrical engineering in 1933, and at the California Institute of Technology, where he received the M.S. and Ph.D. degrees in 1936. In 1937, he became a member of the technical staff of Bell Telephone Laboratories, Deal, N. J. In 1942, he was commissioned as a major in the U. S. Army Signal Corps and assigned to the Office of the Chief Signal Officer in Washington, D. C. For 2 years, he was engaged in co-ordinating development programs for airborne radar equipment and for radar counter-measures devices. He received the award of Legion of Merit for work on these programs. He was transferred in 1944 to the headquarters of the Signal Corps Engineering Laboratories at Bradley Beach, N. J., as chief of the engineering staff. He later became deputy director of the Engineering Division and attained the rank of colonel before returning to civilian life at the close of 1945. Dr. McRae was appointed director of radio projects and television research for Bell Telephone Laboratories in June 1946. He was advanced to the position of director of Electronic and Television Research in 1947. In 1949, he was appointed, successively, assistant director of apparatus development I, director of apparatus development I, and director of transmission development. Dr. McRae was appointed vice-president in charge of telephone systems development in 1951, and 2 years later was elected a vice-president of the Western Electric Company. He also was named president of the Sandia Corporation of Albuquerque, N. Mex. In 1959, he was appointed chairman of the Army Scientific Advisory Panel. He was a former president of the Institute of Radio Engineers and a member of the general advisory committee to the Atomic Energy Commission.

Giacomo Musso (AM '50), chief engineer, Italian State Railroads, Rome, Italy, died recently. He was born December 21, 1901, in Milan, Italy, and was educated at the University of Rome. Mr. Musso was a member of the Associazione Electtrotecnica Italiana.

Hugh F. Shoffstall (AM '24), former engineer at the Bell Telephone Laboratories, died recently. He was born June 15, 1893, in Lake View, Ohio. In 1916, he was graduated from Ohio State University with the bachelor's degree in electrical engineering. He joined the American Telephone and Telegraph Company in 1916 and transferred to the Bell Telephone Laboratories in 1934 where he was employed until his retirement in 1958.

John Leo Welch (AM '27), vice-president in charge of operations, Niagara Mohawk Power Corporation, Syracuse, N. Y., died recently. He was born September 6, 1893, in Syracuse. During 1911-17, he was a helper and electrician for the Syracuse Lighting Company. He served in the U. S. Army Signal Corps in World War I. He returned to the Syracuse Lighting Company in 1919 as an electrician. In 1920, he became electrical foreman for the U. G. I. Contracting Company, Syracuse.

OF CURRENT INTEREST

GIANT BALLOONS, with a volume of 10 million cubic feet, were launched from an aircraft carrier in the Caribbean carrying equipment designed to record very-high-energy cosmic rays. The project, sponsored by the National Science Foundation and the Office of Naval Research, received fleet support from the U. S. Navy, which named the launching operation "Skyhook 60." The over-all scientific program is known as Project ICEF (International Co-operative Emulsion Flights) because about 25 universities and other research institutions representing every continent except Antarctica are participants.

NSF Photo

Electronic Aspects of Operation Skyhook 60 Flights

THE PURPOSE of Skyhook 60 was to launch two, or perhaps three, 10-million-cubic-foot balloons to high altitudes in the Caribbean area. The operation was in support of the high-energy cosmic ray investigations of Dr. Marcel Schein of the University of Chicago, sponsored by the National Science Foundation (NSF) and the Office of Naval Research. The balloons carried giant stacks of photographic emulsion sheets to record primary cosmic ray particles.

Aside from establishment of launching techniques and ship handling methods to bring about a no-wind condition on deck during inflation and launch, two problems had to be solved to assure a reasonable chance of successful flights. The solution to these problems was sought through electronics. First, the probable course of the big balloons had to be predicted. This was done through the use of "tracer" balloons to measure and send back to the ship information on wind velocity and direction at altitude (above 100,000 feet). Second, the balloons had to be tracked and cut down when desired so that the emulsion gondolas could be located and recovered.

To solve the first problem, the *USS Valley Forge* (CVS-45) launched a series of weather balloons during the course of her operations in the Caribbean and Atlantic. These were considerably larger than ordinary weather balloons, stretching up about 175 feet high at time of launching, and with a capacity of 750,000 cubic feet of helium at altitude. They tracked the winds at about 110,000 feet. Like the bigger balloons used for Dr. Schein's emulsion packages—some 500 feet high at time of launch—the tracers were constructed and launched by Winzen Research, Inc., Minneapolis, Minn.

Tracer Balloon Equipment

Altitude reached by the weather balloons was measured by a bellows altitude transducer designed to operate up to 130,000 feet, especially designed for balloon work by the Winzen firm. The bellows, expanding with decreasing pressure, moved a finger on a code drum, which in turn keyed a 1,710-kc 1½-watt low-frequency transmitter. Signals from this instrument were received throughout the tracer balloon flights by the ship's radio system, up to 400 miles away from the balloons.

The tracer balloons also carried an electromechanical timer for cut-down of the balloons. They were preset to whatever flight duration was desired, up to 48 hours.

Finally, each tracer also carried one radar target corner reflector, which the ship's radar was able to track for distances up to 120 miles.

Skyhook Balloon Equipment

The big Skyhook balloons used for carrying the cosmic ray emulsion loads also lifted a considerable amount of electronic supporting equipment. Each carried the same type of altitude transducer and radar reflectors as were carried by the tracers, and all equipment on them was battery-powered by Yardney Silver Cells of 100 ampere-hour capacity.

The first big balloon with a payload—Skyhook Bravo (Skyhook Alpha was a trial balloon of slighter smaller dimensions, with no payload)—carried a 10-channel radio command system, with 6 channels used to make possible valving helium gas, dropping ballast, switching on and off the telemetering transmitter, dropping antennas, and flight termination. The radio command system could be controlled either from the *Valley Forge* or by the tracking aircraft, super-Constellations of the U.S. Navy's "hurricane hunter" squadron in the Caribbean. The radio command system, also a Winzen product, was designed for 80-hour capacity.

Both Skyhook Bravo and Skyhook Bravo Re-fly (the second payload flight, in which the emulsion from the first flight was re-used to get longer flight time) were equipped with "Mytymouse" homing

BALLOONS used during Operation Skyhook 60 carried this Winzen low- and high-altitude beacon. This unit contains two bellows, one for 0 to 60,000 feet, and one for 50,000 to 130,000 feet. There are 450 code groups over each altitude range. The battery supply is under the transducer and transmitter. The entire package is protected by a thermal box. Weight is 9 pounds.

THE Skyhook 60 balloons, carrying emulsion blocks specially designed to record primary cosmic rays or nuclear particles that achieve energies as high as 10,000 Bev (billion electron volts) on their plunge toward earth, were launched from the flight deck of the USS *Valley Forge* in the Caribbean area. The area of the launch was selected because it is near the equator where the earth's magnetic field is strongest. This field provides a barrier to low-energy cosmic rays up to about 10 Bev, effectively filtering them out.

NSF Photo

transmitters developed by the New Mexico Agricultural and Mechanical College. These were 1,685-mc transmitters pulse-keyed by blocking oscillators at repetition rates of 550 and 1,100 pulses per second. Used for recovery operations, they worked extremely well. The first Mytymouse operated from the time of launching until the time of recovery with gondola, with the exception of a short period during flight, and for a considerable time thereafter. Separated from the gondola during cut-down, it continued to broadcast its own position. Because little time could be spared for search, it was abandoned after the payload was recovered.

The second Mytymouse operated below 40,000 feet, controlled by a barometric switch, and did not become separated from the Bravo Re-fly gondola.

Skyhook Bravo also carried the following pieces of electronic and associated gear:

1. A Hastings Raydist altimeter whose output was displayed on a meter, and photographed periodically. Because this was with the Mytymouse instrument package, it was not recovered, so no knowledge was available concerning its operation.

2. A Grimes rotating beacon used for recovery light. It was set to turn on upon descent below 40,000 feet; again, it was with the instruments not recovered.

3. A pressure-type aluminum capsule, which housed the Hastings altimeter and camera, rotating light, and Mytymouse.

The remaining equipment was mounted on the ballast rack.

When aloft, the bright orange gondola containing the emulsion hung from a parachute which was directly below the balloon. Under the gondola swung the ballast rack, a rectangular frame with a line from each corner up to mountings on the gondola. From one corner of the ballast rack dangled the aluminum capsule housing Mytymouse.

Skyhook Bravo Re-fly, not equipped with a 10-channel radio command system, used instead a clock for dropping ballast. This was set prior to ascension. Above the parachute on this flight was a single-channel radio command for flight termination purposes.

Flight Termination

Flight termination, whether by preset timer as in the case of the tracer balloons or upon command as with the payload flights, was accomplished by discharging explosive squibs that cut the lines holding the parachute to the balloon. The loads then descended, in about an hour's time, to the water, while the balloons either shattered from the shock wave caused by sudden dropping of the load, or tore and split from turbulence after the stabilizing loads left them.

The third big balloon, Skyhook Charlie, was not launched successfully owing to excessive stress on some of the cables which caused them to part. The emulsion is expected to be flown at a later date in the United States. EE

Communications System Being Constructed for Brasilia

A high-capacity microwave telecommunications system to link Brazil's remarkable new capital city, Brasilia, with the rest of the world is being constructed by the Radio Corporation of America (RCA), it was announced recently by W. G. E. Vreeland, director, international marketing operations, RCA International Division.

Brasilia is the city fast rising on a plateau about half way between the coast and the Amazon jungle as the first major step toward fulfillment of a century-old Brazilian dream to open up the rich but undeveloped interior of the country.

"This communication system will be vital to the life of the metropolis and to the future development of the region," Mr. Vreeland said. "The system, like the city itself, is being constructed as a 'crash' project, since it must be completed and in operation by April 15, 1960."

Although planned for many years, the city of Brasilia has risen in the short span of 3 years.

The city, occupying an area that had been only grasslands and scrub forest before, will be dedicated by President Juscelino Kubitschek, April 21. Thereafter, government offices, foreign embassies, and many businesses will move there from Rio de Janeiro, 600 miles to the southeast, and ultimately Brasilia will be a metropolis of more than 500,000 population. It is the first major city to be built right from the blueprint stage since Washington, D. C.

The system being installed by RCA will be composed of microwave radio relay stations carrying 120 channels for telephone and telegraph service over routes totaling 810 miles.

It will have 26 relay stations, some of them constructed in rugged mountain territory and some in jungle that is among the least explored and the most impenetrable in the world. These will be mostly unmanned, but serviced periodically.

The system will provide the necessary communications link between Brasilia, as the heart of Brazil's interior Federal District, and the rest of the world through such cities as Rio de Janeiro, Sao Paulo, Juiz de Fora, Belo Horizonte, Uberaba, and Uberlandia.

It was stated that the Brasilia system will be one of the most modern in the world. The contract to build it was signed in Brasilia by the Companhia Urbanizadora da Nova Capital (NOVACAP), the organization responsible for designing and building the ultra-modern city, and RCA and RCA Victor Radio S.A., the company's Brazilian associate. RCA Victor Company, Ltd., in Montreal, Que., Canada, is producing the major portion of the microwave equipment.

To implement the contract, RCA has made complete aerial and ground surveys. It is providing for the installation of the radio equipment, accessories, and power plants, and the training of Brazilian technicians. RCA will operate the system for 6 months after its inauguration, and there is an option for an additional 2 years of operation.

Brasilia will be the consummation of a dream which Brazilians talked about long before the establishment of the country as a republic, independent of Portugal, in 1889, Mr. Vreeland pointed out. In the interests of developing the rich virgin territory in the interior of the country, a constitutional amendment was passed in 1890 authorizing creation of a 4,000-square-mile Federal District in the central state of Goias. But it was not until 3 years ago, under the aegis of the newly elected President Kubitschek, that the development got under way on a major scale.

The city is laid out roughly in the shape of a giant airplane. In the "nose" section have risen majestic marble and glass buildings to house government offices and foreign embassies. In the "fuselage" section, there will be stores, office buildings, theaters, churches, museums, and parks. In the "wing" sections, scores of apartment houses are rising, and on the periphery, there are areas for suburban homes.

Motion-Picture Camera Magnifies Time by 100,000

A CAMERA that can stretch the events of one second into 28 hours is now in production. By combining optical, electronic, and mechanical principles, the new ultraspeed camera can take from 480 to 1,600,000 pictures per second on standard 35-mm film, in black and white or color.

The new camera was developed by Dr. A. T. Ellis, associate professor of applied mechanics at the California Institute of Technology. He originally designed the basic instrument for the express purpose of photographing gas bubbles appearing in turbulent fluids. Such bubbles are born and die within a few thousandths of a second, but during their short life span they produce cavitation, a highly destructive effect in hydrodynamics.

Commercial Model

The improved commercial model, built by the Benson-Lehner Corporation of Santa Monica, Calif., represents the latest research instrument for magnification of time. It permits scientists and engineers to freeze motion while studying arc discharges, explosive reactions, fragmentation processes, high-frequency fatigue, and many other ultrafast events.

Since no mechanical shutter can approach this speed, an electro-optical shutter is used which controls passage of light by means of ultrarapid electric pulses. The shutter assembly consists essentially of two polaroid filters and a cell filled with a special substance in an electric field. When the field is off, no light passes through the assembly. When a high-energy electric pulse is applied, the light is polarized in such a manner that it passes freely through the filters. One or two optical lenses focus the image onto a rotating mirror in the film box.

The film remains stationary while the mirror revolves at the rate of 100,000 rpm. The rotating mirror is a piece of nickel-plated aluminum shaped like a wedge and attached to the staff of a high-speed air-driven turbine. Placed at the center of the circular film box, the mirror directs the light rays to the film so that the image travels along the inside rim of the circular film box.

The speed of operation of the electro-optical shutter is determined by the speed at which the electric field is applied and removed. For the rates required in this camera, a very short pulse of 18,000 volts and 20 amperes is used to control the field. The special pulser system designed for this camera permits effective exposure times of 0.05 to 1.0 microsecond.

Since very intense illumination is needed to provide good resolution at ultrafast exposure rates, the camera is equipped with its own lighting system, capable of producing 400 million lumens with 3 milliseconds duration. This is about 60 times more illumination than provided by the most powerful flash bulb.

The film magazine has a capacity for 400 feet of film. Film advance is push-button controlled, allowing automatic replenishment of the main camera chamber without setup changes. Take-up and feed magazines are separate, permitting individual tests to be processed without reloading or rethreading the camera.

If the processed film were run through a standard projector at 16 frames per second, ultrafast action, undetectable to the human eye, would be slowed down 100,000 times for scientific analysis. The frame size is large enough to show fine detail clearly in individual enlargements.

The new ultraspeed camera has proved very successful in high-speed impact studies, an important area of present research. Such impacts may occur, for example, when meteor particles hit the skin of space vehicles. The resulting stress waves can be made visible by bonding photoelastic materials to metal surfaces. However, the 11,000-mph propagation speed of these waves makes necessary exposure times in the order of 0.05 microsecond to freeze and photograph their motion. Another interesting test involved firing a bullet at 4,000 feet per second into a block of ordinary gelatin, to substantiate the current theory that very-high-speed impacts may cause metals to flow like viscous liquids.

This new tool of advanced research will prove extremely valuable in the fields of missile mechanics and space exploration.

A 30-caliber bullet is fired at 6,500 feet per second into solid plastic plate. Note fluid flow of solid under high-speed impact.

When operated at its lower speeds, it will also stop motion in mechanisms such as cams, relays, springs, breaker points and so forth, permitting visual study of stresses, patterns of vibration, and eventual failures. Besides its obvious scientific importance, ultraspeed photography will also bring improvements in mechanical design not possible by any other methods. EE

THE ELLIS ULTRASPEED CAMERA consists of four units: camera, camera control, lighting control, and electronic flash lamp. Shown (above, *left*) is the actual setup for photography of a cavitation cloud formed in degassed water by ultrasonic sound waves. Above, *right:* This is a typical cavitation cloud. Note rise and collapse of bubbles produced by the agitation of the ultrasonic field.

Project Spin Works Toward Development of Cryogenic Gyroscope

THE STUDY of strange behavior of materials in temperatures near absolute zero is about to yield developments "of great import to mankind," the General Electric Company said recently in announcing progress toward a superaccurate inertial guidance device.

Disclosing an engineering development with kinship to perpetual motion, the company said it has successfully suspended a small metal body in a vacuum and has rotated it at high speed essentially without friction—made possible in part by "complete absence of measurable electrical losses."

The development makes use of characteristics exhibited by certain metals and alloys which at extreme low temperature become "superconductive."

J. F. Young, General Engineering Laboratory manager, declared he is "convinced we are about to enter an era where developments of great import to mankind will stem from application work in this relatively new field." He said the present state of cryogenics work—"superconductivity in particular"—is about where electrical engineering stood in the last half of the 19th century. The laboratory experiments proved the feasibility of suspending and rotating a metal body within a vacuum for long periods, with the object held aloft solely in a frictionless magnetic field.

While ultimate "coast-down" time of an object suspended in this way has yet to be determined, Mr. Young estimated it should be able to spin freely for many months "or even years" after once being set in motion.

The feasibility tests, which he pointed out were financed by General Electric, have led to a development contract with the U. S. Army Ballistic Missile Agency. Identified as "Project Spin," the military contract looks to the perfection of a revolutionary "cryogenic gyroscope."

G. A. Hoyt, ordnance department general manager, said the cryogenic gyroscope will be many times more accurate than the best conventional gyros.

"The reason is that in the cryogenic gyro the general causes of unpredictable gyro error will have been either eliminated or reduced to negligible factors," he said. "And since the world of supercold is a dead world where no chemical or organic change takes place, the sustained reliability of the cryogenic gyro will be vastly higher than that of conventional gyros."

The increased accuracy is seen resulting from elimination of mechanical bearings, reduction of friction and electrical losses "almost to zero," and the heightened dimensional stability induced by the extreme low temperatures.

It was pointed out that a navigation system containing a superconductive gyroscope would permit a submarine or land vehicle to determine its exact position at any point on earth with a precision not otherwise possible except through time-consuming measurements. Such positioning would include highly accurate orientation to true north, necessary for the most exacting accuracy in missile firing.

The developmental gyroscope contains no mechanical bearings and thus no essential parts subject to wear. Feasibility tests show a "virtual elimination" of frictional drag and electrical losses in the gyro rotor.

In subcold induced by liquid helium at a temperature only 4 degrees above absolute zero (—460 F), a golfball-size sphere is presently being readied for advanced tests at rotation speeds up to 20,000 revolutions per minute inside a high vacuum.

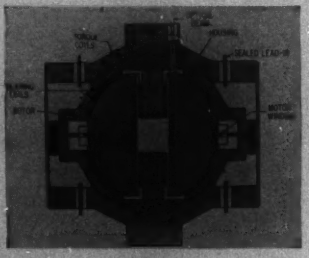
It was explained that when a material becomes superconductive, always at an extremely low temperature, it offers no resistance to the flow of electricity. So complete is its nonresistance that an electric current introduced into a superconductive substance would flow indefinitely unless deliberately interrupted.

A superconductive substance also acts as a highly efficient magnetic insulator—repelling a magnetic field in such a way that the force provides stable support for the suspended body.

Dr. T. A. Buchhold, consulting engineer with the General Engineering Laboratory, declared the uses of superconductive materials for practical purposes "are today at their very beginning."

Entirely within the realm of possibility, he said, is a superconductive magnetic lens applied to an electron microscope. He said that by use of such a lens the enormously increased resolution "should make it possible actually to see an atom."

He also sketched such future possibilities as highly stable frequency and time standards, microminiature switching units for shoebox-size computers, extremely accurate measurement standards for electric current, noiseless and drift-free d-c/a-c amplifiers, and superconductive power lines that could carry "perhaps 10,000 amperes of electricity" over a ½-inch cable. EE



CUTAWAY shows design features of cryogenic gyroscope under development by General Electric Company's General Engineering Laboratory. Promising accuracies many times greater than the best conventional gyroscopes, it features a rotor designed for rotation at high speed inside a vacuum. Superconductivity induced by temperatures near absolute zero makes possible suspension of the rotor solely in a magnetic field. Eliminating mechanical bearings, the design reduces electrical losses and friction almost to zero.

ONCE this golfball-size sphere is set in motion, it may be able to spin freely for years, according to General Electric which said it is an important part of a new superaccurate gyroscope being developed at its General Engineering Laboratory. Engineer K. F. Schoch holds the sphere which will rotate at high speed in a vacuum like a tiny earth, suspended solely by an invisible magnetic field. Development makes use of strange behavior of metals at temperatures near absolute zero (—460 F).

Radar Signal Bounced Back from Sun

For the first time, man has made direct contact with the sun.

A radar signal was sent with the speed of light from the Stanford University (Calif.) campus to the center of the solar system, from which it bounced back to a waiting receiver 17 minutes later, according to a report by scientists of the University's Radioscience Laboratory (formerly the Radio Propagation Laboratory).

The sun was considered one of the most difficult bodies in our solar system to reach by radar, not only because of the stupendous distance, but especially because of the thunderous radio noise arising from its turbulent surface.

The Stanford achievement was disclosed in the February 5 issue of *Science*, a professional journal. The authors are Prof. Von R. Eshleman, Lt. Col. R. C. Barthle, and Dr. P. B. Gallagher.

These initial contracts open the way for intensive solar explorations by radar, using improved techniques and more powerful transmitters.

Scientists hope, among other things, to learn more about solar flares and similar

violent eruptions that hurl streams of particles into space.

These particles, trapped in the earth's magnetic field, form the radiation belts which pose a serious threat to space travel.

Their release from the sun is usually followed on earth by vivid displays of Northern Lights, by magnetic storms, and by complete blackout of long-distance radio communications. They are believed to affect weather, too.

Scientists also are anxious to study disturbances in the sun's outer corona.

The Stanford achievement climaxes radar space explorations that began in 1946 when a Signal Corps group bounced a signal off the moon. The sun, at a distance of 93 million miles, is 400 times farther away.

Radar contact with the planet Venus, 28 million miles away, was announced last year by Massachusetts Institute of Technology's Lincoln Laboratory. The Venus signal took five minutes for the round trip.

The Stanford solar contacts were recorded on magnetic tape at daybreak of April 7, 10, and 12, 1959.

The Stanford group spent months examining the material. Tens of millions of computations were required to separate the signal echoes hidden in the background noise, which was 50,000 times stronger. The final tabulation shows a 99.999% certainty of their results.

Prof. Eshleman said the echo did not come from the sun's visible surface, but from its outer corona. He estimates that the reflection occurred approximately 500,000 miles out.

"Bird" No. 175-4 Sets MACE Record

MACE No. *175-4*, a U.S. Air Force surface-to-surface tactical missile, has been flown and recovered successfully four times —a record unmatched by any other MACE. No. *175-4* was flown three times in 1959, and once in 1960.

The missile, built by The Martin Company, is being used as a training "bird" by Air Force tactical launching teams undergoing MACE familiarization courses at the Missile Development Center, Holloman Air Force Base, N. Mex.

A successful recovery saves taxpayers several hundred thousand dollars, permits more intensive crew training, and allows examination of the guidance system should it malfunction in flight.

The No. *175-4* has lived to fly four times because it carries a parachute recovery kit in place of a warhead.

During a recoverable flight, the MACE is controlled by a radar command system operated by a ground "beeper pilot," who regulates the missile with a small control stick.

When the "beeper pilot" decides to down the MACE, he punches a button which throttles back the missile's jet engine to 60% power and sets controls to bring it to a 2,500-foot altitude. The power setting then is adjusted to maintain the desired speed as the "beeper pilot" positions the missile over the recovery area.

When another button is pressed, three 100-foot cargo chutes open and suspend the MACE in a harness. The can containing the chutes falls away as the 10,000-pound missile floats to earth. Its landing is cushioned by large air bags of rubberized fabric.

MACE No. *175-4* is an "A" version of the tactical missile. It uses ATRAN (Automatic Terrain Recognition and Navigation) guidance developed by Goodyear Aircraft Corp., as do all "A" models.

The self-contained ATRAN system scans the terrain with radar, compares the landscape with a previously prepared film strip in the missile's nose, and makes appropriate adjustments to the flight path as the "bird" flies to its target.

The improved "B" version being tested at the Air Force Missile Test Center, Cape Canaveral, Fla., has a range of 1,200 nautical miles, about twice that of the "A" model now operational with tactical units in West Germany.

The *TM-76B*, in production at The Martin Company's Baltimore Division, uses inertial guidance developed by the AC Spark Plug Division of General Motors.

AN AIR FORCE *TM-76A* MACE tactical missile floats earthward after a successful flight at the Missile Development Center, Holloman Air Force Base, N. Mex. A similar Martin-built "bird"—MACE No. *175-4*—recently set a record by completing its fourth successful recovered flight. A parachute recovery kit carried in place of a warhead permits re-use of the missile.

The self-contained inertial system—which is completely impervious to electronic jamming countermeasures—is a form of memory navigation which enables the missile to "know" the direction and distance it must fly to its target.

The all-weather MACE can carry nuclear warheads of variable sizes and can be launched from a fixed site hardened against nuclear attack. In addition, the missile is adaptable for limited or all-out warfare.

Future Meetings of Other Societies

Building Research Institute, Spring Meeting, Apr. 5-7, Statler-Hilton Hotel, New York, N.Y. M. C. Coon, Jr., 2101 Constitution Ave., N.W., Washington 25, D.C.

ISA, 3rd National Chemical and Petroleum Instrumentation Symposium, Apr. 5-7, Rochester, N.Y. ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

LIA, 32nd Annual Meeting, Apr. 6-7, Chase-Park Plaza Hotels, St. Louis, Mo. D. M. Borcina, Lead Industries Association, 60 E. 42nd St., New York 17, N.Y.

Institute of Environmental Sciences, National Meeting and Exhibit, Apr. 6-8, Biltmore Hotel, Los Angeles, Calif. M. S. Christensen, 6251 Marita St., Long Beach 15, Calif.

13th Annual Conference for Protective Relay Engineers, Apr. 11-13, Department of Electrical Engineering, Agricultural and Mechanical College of Texas, College Station, Texas. L. M. Haupt, same address.

PIEA-PESA, 32nd Annual Conference and Exhibition, Apr. 12-14, Muehlebach Hotel and Municipal Auditorium, Kansas City, Mo. Gene Tuel, Railway Communications, Inc., 9351 E. 59th St., Raytown 33, Mo.

International Symposium on Active Networks and Feedback Systems, Apr. 19-21, Engineering Societies Building, 33 W. 39th St., New York 18, N.Y. Prof. H. J. Carlin, Microwave Research Institute, Polytechnic Institute of Brooklyn, Johnson St., Brooklyn 1, N.Y.

IAS, Symposium on Manned Space Stations, Apr. 20-22, Ambassador Hotel, Los Angeles, Calif. Institute of the Aeronautical Sciences, 2 E. 64th St., New York 21, N.Y.

Society of Technical Writers and Editors jointly with Technical Publishing Society, 7th Annual Convention, Apr. 21-22, Drake Hotel, Chicago, Ill. R. F. Ellis, American Can Co., 11th Ave. & Charles Rd., Maywood, Ill.

AWS, 41st Annual Meeting and Welding Show, Apr. 25-29, Biltmore Hotel and Great Western Exhibit Center, Los Angeles, Calif. A. L. Phillips, American Welding Society, 33 W. 39th St., New York 18, N.Y.

Western Air Conditioning, Heating, Ventilating, and Refrigeration Exhibit and Conference, Apr. 27-30, Shrine Exposition Hall, Los Angeles, Calif., F. J. Tabery, 3443 South Hill St., Los Angeles 7, Calif.

Overseas

Electrical Engineers ASEE, 9th National Exhibition, Apr. 5-9, Earls Court, London, England. Electrical Engineers ASEE, Exhibition Ltd., Museum House, Museum St., London, W.C.I.

Industrial Latin American Partnership Exhibition, Apr. 1960-Oct. 1961, Parque Ibirapuera, Sao Paulo, Brazil. E. L. Neville, ILAPE Representative, 60 E. 42 St., New York 17, N. Y.

Conference on Automatic Computing and Data Processing in Australia, May 24-27, Univ. of Sydney and Univ. of New South Wales, Australia. C.H.D. Harper, Australian Natl. Committee on Computation and Automatic Control, The Institution of Engineers, Science House, 157 Gloucester St., Sydney, Australia.

8th International Automobile Technical Congress, May 9-13, The Hague, Netherlands. General Secretariat, 14, Burgemeester de Monchyplein, The Hague, Netherlands.

International Congress on Microwave Tubes, June 7-11, Munich, Germany. R. D. Paine, Jr., National Science Foundation, Washington 25, D.C.

International Conference on Large Electric Systems (CIGRE), 18th Convention, June 15-25, 112 Boulevard Haussmann, Paris 8, France.

AERIAL VIEW of the CERN nuclear research laboratories. At the left can be seen the 25-billion-electron-volt (25 Bev) alternating gradient proton synchrotron, world's biggest atom smasher. In the foreground are the large experimental halls in which the high-energy nuclear physics experiments are carried out and, to the rear of these, is the huge ring building, 656 feet in diameter, embedded in the earth, in which protons are accelerated up to 99.94% of the speed of light. This machine is the joint realization of the 12 European founding member states of CERN. The site is near Meyrin, Geneva, Switzerland.

CERN Inaugurates 25-Bev Proton Synchrotron

The CERN 25-billion-electron-volt (Bev) proton synchrotron—familiarly called "PS" by the "Cernese"—was officially inaugurated on February 5, 1960.

The European Organization for Nuclear Research, known as CERN, is a multinational organization which works exclusively in the field of pure and fundamental research; it is not concerned with the applications of nuclear energy, whether pacific or military.

Completed after 6 years of joint effort by the 12 founding member states of CERN, the particle accelerator, or atom smasher, is the biggest in the world.

The protons to be accelerated are produced from atoms of hydrogen gas by an ion source. They then enter a "Cockcroft-Walton" preaccelerator where they undergo initial acceleration up to 500,000 electron volts. After this they are again accelerated in successive steps by a linear accelerator which brings them up to a kinetic energy of 50 million electron volts, or an injection speed of about one third of that of light.

Thus, the particles reach the end of the injection system. In 6 microseconds they are injected through the inflector into the synchrotron proper. The vacuum chamber which serves as their "race-course," is a ring-shaped structure 2,060 feet, or more than one third of a mile in circumference.

Here the protons are accelerated by electric fields as they race through the 16 accelerating cavities located round the ring.

In addition, an increasing magnetic field produced by 100 magnet units keeps the beam of particles focused on the 656-foot-diameter orbit within the vacuum chamber, 5.6 by 2.8 inches cross section. Pick-up electrodes, by ascertaining the position of the proton beam relative to the side walls of the vacuum chamber, contribute to this performance, which is remarkable because of the aforementioned dimensions and because in the 1-second duration of the acceleration cycle, the protons go round the vacuum chamber almost 480,000 times. Their trajectory, therefore, exceeds three quarters of the distance between the earth and the moon.

When the process of acceleration is finished, the velocity of the particles reaches 99.94% of the speed of light, about 186,000 miles per second. It is at this point that their energy is 25 Bev.

With increasing velocity, the protons also increase in mass, thus confirming once again an essential part of Einstein's theory of relativity. In the case of the CERN machine, for example, the protons increase in weight by 25 times.

The beam of very-high-energy—and much heavier—particles can then strike a target in the vacuum chamber itself. The fragments of the atoms disintegrated in impact, as well as any new particles created by the conversion of energy into mass, are then observed and studied by means of photographic emulsions and other techniques.

Alternatively, the beam may be ejected at a given point and directed into one of the two large experimental halls toward the counters and the bubble chambers or cloud chambers by means of which they can be studied.

There is, inevitably, a certain danger in the radiation produced by the collision between the high-energy protons and the atoms in their path, and strong barite concrete shielding has been installed as a protection. For the same reason, the machine is operated and the experimental results recorded by remote control from control stations and counting rooms linked to the vital sections of the synchrotron by a network of cables and wires totalling some 2,200 miles.

The successful completion of this accelerator gives Europe a unique tool for research on the internal structure of the atomic nucleus. Yet its financial outlay, some 120 million Swiss francs, represents the cost of a few cigarettes per capita of the 460 million inhabitants of Europe, as has been pointed out by the Geneva journalist, Bernard Béguin.

"Lite Scope" for Television Receivers

The "Lite Scope," developed for television receivers by Hoffman Electronics Corp., provides an automatic means for adjusting the brightness (and, indirectly, the contrast ratio) of the television picture as the ambient illumination in the viewing area changes.

The advantages of remote control, wherein the television set can be turned on or off, loudness varied, channels changed, etc. are severely minimized if an unsatisfactory picture results.

Recognition of this basic fact initiated a project to provide a means for automatically controlling picture brightness and contrast as the viewing ambient light changes.

A considerable amount of experimenting was done before agreement was reached as to the achievement of desired results—which are defined as the optimization of brightness and contrast in complete darkness and various degrees of ambient from 0.1 to more that 1,000 foot lumens of illumination.

The circuit evolved actually provides a brighter picture under exceptionally high ambient illumination (as found in some dealer's showrooms, for example) than any other competitive television receiver tested.

However, under what is called normal viewing, it provides a longer gray scale

TELEVISION receiver with Hoffman "Lite Scope."

with more of that intangible "photographic quality" which is so hard to achieve with the usual receiver.

Both of these advantages are accomplished by causing the "Lite Scope" to adjust the television picture tube cathode load resistor. In addition, a notable advantage is obtained under "normal"

viewing conditions. When a shift is made from "live" programs to "old movies" the extra length of the gray scale provided does much to enable the viewer to discern detail ordinarily obscured in old movies.

Statistics on Engineering Enrollment

For the second consecutive year, enrollment in America's accredited engineering colleges has dropped.

This Fall 240,063 students registered in engineering; last year there were 249,950; and in the Fall of 1957 the total was 257,777.

Under the influence of high enrollments in the mid-1950's, the number of engineering graduates continues to rise; in the year ending in June 1959, 41,132 degrees were given in various fields of engineering. But a study of recent enrollments would indicate that there will be fewer engineering graduates within the next 1 or 2 years, according to the American Society for Engineering Education (ASEE).

The Society released its annual survey of enrollments in schools having accredited engineering curricula recently. The figures, compiled by the U.S. Office of Education, come from 154 engineering schools in the United States and are assembled each year under a joint ASEE–Office of Education project; they cover all engineering colleges with one or more engineering curricula accredited by the Engineers' Council for Professional Development.

Total engineering enrollment in the Fall of 1959 was down 4% from 1958 and 6.9% from 1957, according to the survey. A decrease in undergraduate enrollment first reported in 1958 continued in 1959 with a 5.7% drop during the year. These engineering enrollment decreases came at a time when total college enrollments were rising—in all, by 10.9% during the 2-year period. In 1959, engineering students accounted for only 7.1% of all college students compared with the high of 8.4% in 1957.

B. R. Teare, Jr., president of ASEE, states, "This continued decrease in enrollment, and particularly the decrease in freshmen, is a matter of great concern to all of us. The studies of the Engineering Manpower Commission indicate not only that the demand for engineers is increasing, but also that it is expected to accelerate. . . . If the industrial growth of the country and the defense programs are not to be impaired, the trend of the past 2 years must be reversed."

Engineering enrollments for advanced degrees continued to show increases in the Fall of 1959, but the rate of growth is decreasing, according to the ASEE–Office of Education figures. Of the 34,731 graduate students this Fall, 28,734 were registered for the master's degree; 357 for professional degrees; and 5,640 for doctor's degrees. This represents a 6% increase in master's and 18.4% increase in doctor's registrants over the previous year.

Of the 41,132 engineering graduates who received degrees during the year ending in June 1959, 33,695 earned bachelor's degrees, 7.9% more than in 1958 and 21.4% more than in 1957. There were 6,723 master's degrees, a jump of 16.9% in the year and 29.2% in the 2-year period. The 714 doctor's degrees represented an increase of 10.4% over 1958 and 19.8% over 1957. Engineering accounted for 9.5% of all master's degrees given in 1959 and 7.7% of all doctor's degrees.

The report of engineering enrollments released by ASEE was compiled by W. E. Tolliver of the Higher Education Statistics Unit in the U.S. Office of Education and Dr. H. H. Armsby, chief for engineering education in the Office of Education's Division of Higher Education. A full report was published in the February 15 issue of the *Journal of Engineering Education*, official monthly of the ASEE.

Radar's-Eye View of Atlas

RADAR'S-EYE VIEW of a U.S. Air Force Atlas ICBM (*right*) as it roars aloft from its launching pad at Cape Canaveral, Fla. The precision tracking radar is a part of the General Electric (GE) radio-command guidance system for the Atlas. This composite photo is a view from inside the white radome as radar antennas silently prepare to measure the missile's position and velocity with a high degree of accuracy and reliability. The photo, showing the public a closeup of the antennas for the first time, is technically impossible to take simultaneously with a single snap of the shutter—both because of photographic reasons and operational considerations concerning the radar. However, as shown, it accurately portrays what the tracking radar "sees." The defense systems department of GE has prime responsibility for Atlas' radio-command guidance under Air Force contracts covering development, production, installation, field testing.

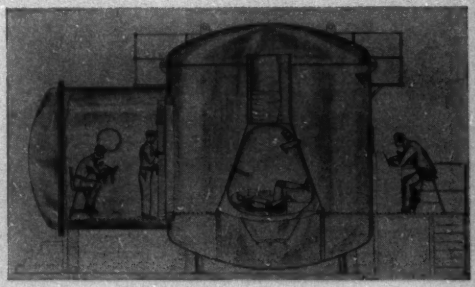
Altitude Simulator For U. S. Astronauts

American astronauts will slip into space without leaving the launching pads of Cape Canaveral, Fla., by means of a huge altitude simulator being built by Tenney Engineering, Inc., Union, N.J.

The tank, an extremely-high-altitude chamber ordered by the National Aeronautics and Space Administration for Cape Canaveral, will accommodate the Project Mercury capsule in which the nation's first space travelers will be launched into orbit. It will simulate an altitude of 225,000 feet with dive rates, so that the astronaut and his space vehicle will function as if they had been hurled into the heavens and were returning to earth, according to R. H. Brown, vice-president of Tenney.

The astronaut, flat on his back with his knees cradled in a sitting position, will be linked to the outside world by a man-made umbilical cord which contains oxygen system, intercom system, and a myriad of test control signal conductors. Windows and ports in the high-altitude chamber will enable doctors and others to view reactions in the simulated void.

It was stated that the chamber holding the Mercury capsule will be 12 feet in diameter and 15 feet high. The capsule itself will be lowered into it through a top lid. An adjoining air-lock or anteroom will go up one third of the way, or 45,000



ARTIST'S CONCEPTION of the altitude simulator being constructed by Tenney Engineering, Inc., for the Project Mercury capsule.

feet, and is for observation and use as a safety entrance.

Special instrumentation will control the vacuum surrounding the capsule. Normal "diving" will be controlled from 0 to 50,000 feet per minute, it was stated, but in an emergency the chamber will be capable of reaching sea level from 225,000 feet in 6 seconds.

Compact Lighting System Has Highway and Auto Potentials

A compact lighting system with a brightness level 338% greater than any fluorescent unit commercially available was demonstrated recently by Sylvania Electric Products Inc. Sylvania is a subsidiary of General Telephone & Electronics Corporation.

H. F. Callahan, vice-president and general manager of Sylvania's Lighting Products Division, said the system—which combines a newly developed aperture lamp and an optically controlled fixture—"represents a startling brightness gain to 22,000 foot lamberts compared to the 6,500 level achieved only last year."

Called the Sylvania Controlled Powerbeam System, the new unit throws a narrow band of light for a considerable distance with a minimum amount of glare.

O. H. Biggs, vice-president–research and engineering of the division, said the unit will have extensive use in low-mounted highway lighting, bridge and tunnel lighting, expressway turn-offs, service stations, building facade floodlighting, and edge lighting for signs.

One potential application is its use as a linear fluorescent automobile headlight. A prototype headlight using the new method was demonstrated along with low-mounted highway fixtures. The experimental headlight extends across the grille of a car between conventional incandescent headlamps.

"With the new system we can distribute light uniformly immediately in front of, and to the sides of a car with vertical cut-off," Mr. Biggs said.

"This means that pedestrians at the side of a vehicle can be readily seen. Tests have shown that the new system is equal to or better than the present incandescent low beam in distributing light evenly on a highway," he added. "When used in conjunction with the high beam, the system is ideal for high-speed driving and gives the advantages of the fluorescent lamp's greater efficiency and longer life."

In addition, the unit's very sharp vertical cut-off keeps glare from reaching the eyes of oncoming drivers, offering a great safety feature.

Mounted on 3-foot-high standards, the highway system has two fundamental points of departure: reduction of glare to a minimum, and uniform distribution of light over the highway surface.

These are achieved by utilizing an intensely bright fluorescent aperture lamp and spreading its beam as a sheath across the desired area by using an optically controlled fixture, it was stated. The light output is directed onto the road at a low angle and is prevented from shining above the horizontal plane. The method makes objects stand out more brilliantly than before and prevents glare from reaching the driver's eyes.

Low-mounted lighting of expressway turn-offs has the important safety feature of clearly defining the separation of thoroughfare and exit. Strips of lights trace the exit route and can be interpreted clearly from a safe distance.

The Sylvania lamp in the powerbeam unit is a VHO (Very High Output) lamp with a special reflective interior coating. Light emits from the tube through an optically precise window or aperture. The light is reflected to the desired area by the fixture.

BMEWS Missile Tracker

First of the giant radar tracking antenna structures for the U.S. Air Force's Ballistic Missile Early Warning System (BMEWS) has been completed by Goodyear Aircraft Corporation, Akron, Ohio, and is undergoing tests at Moorestown, N. J., by the Radio Corporation of America (RCA).

ONE potential of a new compact lighting system demonstrated by Sylvania is this automobile headlight. The unit permits an even distribution of light to the front and to the sides of the vehicle with a very sharp vertical cut-off. This permits the driver to see objects more clearly and keeps glare from the eyes of an oncoming driver. The new linear headlight is shown extended across the grille of a car mockup between the conventional incandescent headlamps.

ERECTED in Goodyear Aircraft's giant Airdock is the first of the BMEWS radar tracking antennas. Taller than an 8-story building, antenna and support pedestal weigh nearly 375,000 pounds. The dish has precision rotating capability and can complete a scan of the skies in a matter of seconds. Goodyear Aircraft is building the antennas and enclosing 140-foot plastic radomes for RCA, prime BMEWS contractor.

Giving the appearance of a giant birdbath, the antenna is among the largest ever built. Pedestal and antenna weigh nearly 375,000 pounds, yet despite this great weight, the dish has precision rotating capability and can complete a scan of the skies in a matter of seconds. The pedestal is nearly 50 feet high.

Goodyear Aircraft is under contract with RCA, prime contractor for the detection system, and the Air Force, to produce the BMEWS radar structures as well as 140-foot-diameter rigid plastic spherical radomes to protect the units from the elements.

The units will be used in the detection and early warning of attack from enemy intercontinental ballistic missiles. BMEWS stations will be located at Thule, Greenland; Clear, Alaska, and at a third site.

At a BMEWS installation, a hostile missile will be picked up by radar, while electronic computers determine its path in order to give about a 15-minute warning as to probable location of point of impact.

Prior to delivery to Moorestown, the tracking antenna was assembled and mechanically tested in Goodyear Aircraft's Akron plant. Despite the 84-foot diameter, Goodyear Aircraft was able to do all the work under roof, using the 211-foot-high Airdock that is the setting for the construction of nonrigid airships for the Navy's aircraft early warning operations.

The over-all BMEWS program is being managed by the Air Force Ballistic Missile Early Warning System Project Office in New York, under the direction of the Air Materiel and Air Research and Development Commands.

Wear Your ◆ AIEE Badge

Ultrasonic Gauging of Missile Components

Gauging of reinforced plastic nose cones and radomes at Brunswick-Balke-Collender Co., Marion, Va., used to take days, sometimes a week. Now, using the Vidigage (registered trade mark) ultrasonic resonance gauge, made by Branson Instruments, Inc., Stamford, Conn., the same job takes only a few hours. At Brunswick, two of these units, used to check exacting dimensions of reinforced plastic nose cones and radomes, have noticeably speeded completion of top-priority defense projects.

Formerly, separate checking fixtures had to be built for each different component. Parts were frequently measured, reshaped, and repositioned on the fixture. Now, thickness is read directly on a calibrated scale, without removing the nose cone from its mandrel or mold. Because of the instrument's speed and reliability, a 2-man team can measure the 4,000-plus check points of a B-58 nose radome in less than a day.

Not only must many thousands of measurements be made, but tolerances at each point are very small. For example, a B-58 jet bomber nose radome has a permissible wall thickness variation of ± 0.005 inch; a submarine radome must be held to ± 0.002 inch; and filament-wound nose cones have a tolerance of only ± 0.001 inch. Because electrical transmission of radar waves is adversely affected by thickness variations, gauging assumes critical importance.

Holding such precise tolerances is difficult because of the size of some cones—up to 12 feet long, with aft-end diameters up to 6 feet. Getting accurate measurements is complicated by flexing of the relatively thin part, which changes its shape and dimensions.

Many of the parts must be built oversize, and then machined or sanded to critical dimensions. Here, repeated gauging is needed to ensure exact tolerances—a matter of repositioning the part in a measuring fixture countless times. Gamma ray devices, air gauges, standard deep-throated calipers, or banks of dial indicators were tried, but were time-consuming or erratic in result.

The Vidigage has solved these measuring difficulties. With the accuracy of a micrometer, it can measure thickness of materials such as metals, plastics, or glass, even when access to only one side is possible. Thus, dimensions of a nose cone can be determined while still on a mandrel or over a mold. Because the piece is supported, there is no flexing or deviation in shape, so that readings are more accurate.

With measurements taken before the component is removed from its mold, alterations can be made on the spot, and the part immediately rechecked for accuracy. Length, diameter, or contour of the cone are immaterial. One ultrasonic gauge can handle any size or shape, without the need for special jigs or fixtures. Mounted on a wheeled dolly, the instrument is fully portable, for ready use in any shop location.

Accuracy of the gauge is guaranteed to within 1.0% of actual thickness over a wide scale range, and measurements to within 0.001 inch are routinely possible. At Brunswick, thicknesses usually range from 0.020 to 0.500 inch. Several times daily, the gage is quickly recalibrated on a piece of plastic of the same composition as that of the cone under test. Checks with micrometers have consistently confirmed the reliability of the instrument.

REINFORCED plastic nose cones are fashioned over a steel mold (above); several layers of glass cloth and resin are applied and smoothed to contour. After final layer is in place, polyvinyl alcohol bag is pulled over the layup, so that a vacuum may be drawn. The nose cone is then cured under a bank of ultraviolet heat lamps, visible in the rear. Below: Nose cone of a Bomarc missile receives a final thickness check by means of an ultrasonic resonance gauge, at Marion (Va.) plant of Brunswick-Balke-Collender Co. Three vertical traces on the cathode-ray screen permit thicknesses to be read directly on a suitably calibrated scale, to the design tolerance of ± 0.001 inch. Because Vidigage requires access to only one side, thicknesses at specified points of nose cone may be checked quickly and accurately, even when the part is still on the mandrel.

The Vidigage operates as follows: A continuously varying frequency, produced by an electronic sweep oscillator, is changed into mechanical vibrations by the transducer and transmitted into the plastic. At certain frequencies, characteristic of the type and thickness of the material under test, harmonic resonances are set up which appear as one or more traces on the cathode ray tube, similar to that used in a television set. By placing suitably calibrated scales in front of the tube, thickness can be read directly. With only a few hours of instruction, a semiskilled operator obtains consistent and reliable results.

Electronic Devices Collect Earthquake Information

The first of several special electronic devices have been lowered to the floor of San Francisco Bay (Calif.) to begin collecting earthquake information necessary for construction of the Bay Area's proposed new $115 million underwater rapid transit tube.

The devices, which will remain in operation for approximately 2 years, were placed in three separate holes drilled in the underlying mud and rock, at levels of 250 feet, 160 feet, and 110 feet below the surface of the water.

Earthquake vibrations recorded during the 2-year study will be used to establish design specifications and to select the best depth for construction of the 4-mile transit tube connecting Oakland and San Francisco.

Three of the seismic measuring devices —called geophones—are being installed in each of the three underwater holes, as well as a like number of spares to be utilized in case of malfunction. All are sealed in special watertight steel jackets to protect the instruments from corrosion.

The geophones in turn will be connected by underwater cable to telephone lines on the nearby Bay Bridge, and from there the seismic waves will be transmitted electronically to recorders located in the downtown San Francisco offices of Bechtel Corporation, one of the engineering consulting firms for the rapid transit district.

So sensitive are the underwater geophones that their power to pick up seismic waves must be reduced approximately 200 times in order to be effective for the study.

"Otherwise, they would be picking up vibrations from every car and truck which pass overhead on the Bay Bridge and from every ship that moves across the water," said R. J. Swain, chief of structural seismology for United Electrodynamics Inc., the firm which is installing the special equipment.

Aluminum Cable Provides Savings for "Push-Pull" Trains

The "push-pull" commuter trains of the Chicago and North Western Railway display a unique use of aluminum power cable.

Serving the trains' all-electric heating, air conditioning, and lighting equipment, the cable is secured openly beneath each

PUSH-PULL commuter cars being used by Chicago and North Western Railway are 10 tons lighter than conventional 2-decker cars and less expensive to build. One place money is saved is in installation of aluminum power cable. Each car employs 1,200 feet of 250-MCM single-conductor rubber-insulated neoprene-sheathed cable supplied by Kaiser Aluminum & Chemical Sales, Inc. Cable, which feeds power to lighting, heating, and air conditioning units in cars, costs 30% less than equivalent copper cable. Above: aluminum power cable is seen in open installation beneath train.

car in a simple, economical installation. The aluminum cable provides a 30% savings in cost compared to the equivalent copper cable.

The new double-decker trains have been designed to eliminate the terminal switching operation. A locomotive pushes each one into Chicago and pulls it back to the suburbs. When the locomotive is pushing from the rear, the engine crew controls the train from a cab in the leading car.

The 480-volt 3-phase power from a diesel-driven alternator on the locomotive is transmitted to each car through 250-MCM single-conductor aluminum cable. The rubber-insulated neoprene-sheathed cable, supplied by Kaiser Aluminum & Chemical Sales, Inc., is installed in four runs of three cables each cleated to the underside of the cars. Each car requires 1,200 feet of cable.

Connection between the cars is made by four trainline jumpers and receptacles, each having three main power and three control contacts.

Because the push-pull cars are not burdened with electric generators and steam pipes, it was possible to design them to weigh 10 tons less than conventional double-deck units.

"Photomasking" Used in Instrument Panels

A new method of integrally lighting instrument panels has been developed by Simmonds Aerocessories, Inc., Tarrytown, N.Y.

The new design, technically known as "Photomasking," consists of a process of photomechanically blending a half-tone pattern on the rear surface of an instrument dial face to create a uniformity of lighting throughout the dial. This pattern is etched in a material that will withstand temperatures well over 150 C. This is far in excess of temperatures generally encountered in the most severe operations.

By photomechanically etching this pattern of dots, the costly, but heretofore necessary procedure of hand balancing the entire instrument panel has been eliminated.

Photomasking is applied at such a level as to eliminate all after vision completely. Other features of photomasked dials are freedom from warping, discoloration, objectionable stray light, and the expansion and contraction problems encountered in today's sophisticated weapons systems.

Photomasking is designed and manufactured to meet the requirements of MIL-L-25467A for Aviation Red and MIL-L-27160 for white light. A partial listing of aircraft presently using Simmonds integral lighting includes the F-105D, and E, the B-58 Hustler, F8U-3 Crusader, and the A4D2N.

Electron Tube To Explore Space-Age Communications

An electron tube, described as the world's most powerful, has been developed by the Radio Corporation of America (RCA) for possible future use in outer-space communications, intercontinental television, and industrial applications.

The new tube's average power output is four times greater than any existing tube at its frequency rating, according to D. Y. Smith, vice-president and general manager, RCA Electron Tube Division.

ELECTRON TUBE—said to be world's most powerful—is guided into a test chamber at RCA's Lancaster, Pa., plant by Gerald Brill, an engineering technician. The tube will be subjected to rigorous electrical tests which simulate the actual operating conditions of an ultrapowerful transmitter. The tube, weighing approximately 150 pounds, can produce 5 million peak watts of long-pulse power at 450 mc.

It provides enough power, he said, to transmit a television picture halfway around the world by using the technique of bouncing a signal off a metallic balloon or other object in outer space.

"While the tube is only 17 inches in height and 14 inches in diameter—about the size of a nail keg," Mr. Smith said, "it can produce 5 million peak watts of long-pulse power at an average power level of 300,000 watts and at a frequency of 450 mc.

"This developmental tube has the potential ability to deliver enough r-f power to explore the possibilities of outer-space communications, intercontinental television, missile guidance, superpower radar and scatter transmission on a global scale," he added.

"It also is capable of generating superpower for industrial applications such as electronic heating, radiology, irradiation, and sterilization."

It was stated that the new tube, known as developmental type *A-2346*, delivers its tremendous power with a pulse duration of 2,000 microseconds and a duty factor of 0.06.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

THE NATIONAL FIRE CODES, Volume V, Electrical. Published by the National Fire Protection Association, 60 Batterymarch St., Boston 10, Mass., 1959. Various pagings, 5¼ by 8¼ inches, bound. $7. The standards developed by the National Fire Protection Association and compiled into the National Fire Codes are intended as guides in the solution of fire safety problems wherein several standards may be pertinent, and are widely used as a basis of good practice in the protection of life and property. This volume contains the National Electric Code and Standards for electrical fire alarm and supervisory service, lightning protection, and static electricity, with revisions to June 1959 where applicable.

SYSTEMS OF UNITS: NATIONAL AND INTERNATIONAL ASPECTS. Edited by C. F. Kayan. American Association for the Advancement of Science, 1515 Massachusetts Ave., N.W., Washington 5, D. C., 1959. 297 pages, 6¼ by 9¼ inches, bound. $6.75. International exchange of technical information would be greatly promoted by a more nearly universal system of units. To focus attention on the growing problems of unit usages, this symposium presents authoritative discussions from the United States and abroad dealing with English vs. metric units and the absolute vs. the gravitational (technical) system. Treatment of the mksa system also is included.

ADVANCES IN SPACE SCIENCE, Volume I. Edited by F. I. Ordway, III. Academic Press, 111 Fifth Ave., New York 3, N. Y., 1959. 412 pages, 6½ by 9½ inches, bound. $12. Embracing nearly all phases of human scientific knowledge, space science has the principal objective of manned space travel and exploration. Bioastronautics which concerns human aspects of space travel is treated directly in articles on manned space cabin systems, the effect of za-

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diation on man in space, and the nutritional aspects of space flight; and indirectly in articles dealing with orbits and interplanetary trajectories, interplanetary communications, and the problem of power supply on board orbital and space vehicles. The latest revision of the Sänger system for the classification of astronautical literature is included as an appendix in this first volume of a projected annual publication.

ANNUAL REVIEW OF NUCLEAR SCIENCE, Volume 9. Edited by Emilio Segrè, and others. Annual Reviews, Inc., Palo Alto, Calif., 1959. 625 pages, 6½ by 9 inches, bound. $7. The papers in this annual review cover varied aspects of nuclear science and technology, and the developments and recent experiments in these fields are described. Photodisintegration, the pion-nucleon interaction, strange particles, and beta-radioactivity are in the area of physics; technetium and astatine chemistry and solvent extraction in radiochemical separations are the contributions in chemistry. Plasma research, electronics in nuclear research, and fast reactors are among the general papers, and there are several articles on the biological aspects of radiation.

ASTM STANDARDS ON ELECTRICAL INSULATING MATERIALS. Published by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 1959. Various pagings, 6 by 9½ inches, bound. $8.75. Collected in this volume are standard and tentative specifications, methods of test, and recommended practice relating to electrical insulating material. Forty-six of these are new, revised, or have had their status changed since the previous edition in 1957. Included also are three proposed methods of test in draft form, for the purpose of soliciting critical comments.

BEAM AND WAVE ELECTRONICS IN MICROWAVE TUBES. By R. G. E. Hutter. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J., 1960. 378 pages, 6½ by 9½ inches, bound. $9.75. An introductory text designed to provide a basic understanding of microwave tubes, this book analyzes the fundamental physical principles of a wide range of microwave devices, from klystrons and magnetrons to the most recent traveling-wave tubes. The logical exposition moves from schematic description of conventional tubes, through microwave circuitry, the principles of beam and wave electronics, and the conversion of d-c to r-f energy, to more complicated theories of microwave tube operation, and a systematic study of the subject of noise. Theoretical concepts are clearly developed throughout before being utilized to examine operational characteristics.

CLASSIFICATION AND INDEXING IN SCIENCE. By B. C. Vickery. Second edition. Academic Press Inc., 111 Fifth Ave., New York 3, N. Y., 1959. 235 pages, 5½ by 9 inches, bound. $6. The modern techniques of subject analysis of scientific and technical literature are discussed, with methods of constructing classification schedules for indexing, particularly "facet analysis," and the application of a notation to the schedules for card indexing. In this new edition the accounts of alphabetical and classified indexing are expanded; indexing of chemical substances is included; new American techniques and mechanisms for information retrieval, and the developments at the 1958 Washington Conference on Scientific Information are covered. The appendices trace the history of classification in the sciences, and classification schemes for soil science, astronomy, nuclear energy devices, food technology, and container manufacture are outlined.

ECONOMIC CONTROL OF INTERCONNECTED SYSTEMS. By L. K. Kirchmayer. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1959. 207 pages, 6 by 9¼ inches, bound. $12.50. This book deals primarily with the treatment of mathematical methods, computers, and controllers to obtain the optimum economic operation of interconnected electric utility systems, describing pioneer methods in operation applicable to all process industries. Included is discussion of important tools for the development of optimalizing computer controllers, such as theoretical and differential analyzer performance prediction methods, development of mathematical models of process, and use of advanced circuit methods.

HANDBOOK OF INDUSTRIAL RESEARCH MANAGEMENT. Edited by Carl Heyel. Reinhold Publishing Corporation, 430 Park Ave., New York 22, N. Y., 1959. 513 pages, 6¼ by 9½ inches, bound. $12. This volume provides a guide for the organization, evaluation, and control of industrial research. For those in top management the book can be a yardstick and a guide to controlling and evaluating this costly operation; for directors of research, administrative problems are dealt with; for their executive directors, the day-to-day details and responsibilities are presented; and for financial executives there are papers on accounting and budget control of the research function. The final chapter discusses Government contracts.

HOCHSPANNUNGSTECHNIK. By Arnold Roth. Fourth edition. Springer-Verlag, Vienna, Austria, 1959. 756 pages, 7 by 10 inches, bound. $39. The new edition of this German work on high-tension technique, incorporates all changes and innovations in the field since the third edition (1950). There are new chapters on the increased efficiency of transformers of relatively smaller dimensions and on switching installations and switches which today are meeting the demands of considerably higher power loading. Also considered is the progress in creating high d-c voltage, in the technique of X-ray tubes, and in high-tension equipment for nuclear physics. There is an extensive bibliography arranged according to chapters.

IMPULSE-VOLTAGE TESTING. By W. G. Hawley. Chapman & Hall Ltd., London, England, 1959. 188 pages, 5⅛ by 9¼ inches, bound. 32s. This monograph is devoted to impulse-voltage techniques and testing, including the basic theory which is dealt with in terms of the Heaviside operational calculus. These tests are recommended with the object of determining the effect of voltage surges of short duration on electrical installations and their individual parts, the surges being such as are caused especially by lightning discharges. Single-stage and multistage impulse generators, including miniature apparatus, measurement and recording of voltages, and considerations of specific situations are covered.

LAPLACE TRANSFORMS FOR ELECTRONIC ENGINEERS. By J. G. Holbrook. Pergamon Press, 122 E. 55th St., New York 22, N. Y., 1959. 259 pages, 5½ by 8¾ inches, bound. $10. This self-teacher for practicing electronics engineers requires a knowledge of college-level differential and integral calculus and graduate circuit analysis. It is designed to give a thorough practical knowledge of the Laplace transform theory, which enables complete analysis of electronic network problems. The author avoids the abstract terminology of pure mathematics, and devotes his first chapter to a review of complex variable theory as applicable to the Laplace transform, necessary to the derivation of the Laplace integral. The remainder of the book develops and demonstrates applications of the Laplace transform theory.

LINEAR CIRCUIT ANALYSIS. By B. J. Ley and others. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 567 pages, 6 by 9½ inches, bound. $12.50. The fundamentals of linea, lumped circuit theory are presented, including the formulation of network equations and their solution in the time domain by classical methods or in the frequency domain by Fourier & Laplace transforms. Electrical and mechanical analogs are treated in order. To show a general method of analysis specified by simultaneous integrodifferential equations. The text also deals with topology, the cut-set method of writing circuit equations, the use of matrices in their formulation, scale factors in analogs, and mechanical circuit theorems.

NONDESTRUCTIVE TESTING HANDBOOK. Edited by R. C. McMaster. The Ronald Press Company, 15 E. 26th St., New York 1, N. Y., 1959. 2 vols., 6¼ by 9½ inches, bound. $24. This is a comprehensive reference work on the major methods of nondestructive testing dealing with the measurement of significant properties, detection of discontinuities, and prediction of performance capabilities without impairing serviceability. It combines principles and data to provide a full explanation of test methods and applications, equipment and techniques, and acts as a guide for the interpretation of the tests to evaluate the serviceability of the test objects. X-ray processes, electrified-particle and magnified-particle tests, ultrasonic tests, liquid-penetrant tests, and visual techniques are among the major areas covered. Several comparatively new techniques such as immersion ultrasonic testing, isotype radiography, and eddy-current testing are presented as well. The book can be used as a basis for setting up test programs.

NOTES; BASIC ENGINEERING SCIENCES. By C. E. Harrington. Fourth edition. Published by author, 45 Elk St., Springville, N. Y., 1959. 169 pages, 8½ by 11 inches, paper. No price given. A brief review of engineering fundamentals with answers to 200 problems, asked in the New York State Board Examinations for the Professional Engineering License, are contained in this book. This fourth edition has been enlarged to include several new subjects and much of the text has been rewritten. It has been found helpful as a reference book for those working in industry as well as for home study for the Board examinations.

NUCLEAR FUEL ELEMENTS. Edited by H. H. Hausner and J. F. Schumar. Reinhold Publishing Corporation, 430 Park Ave., New York 22, N. Y., 1959. 409 pages, 6¼ by 9¼ inches, bound. $12.50. Papers presented by United States and European scientists at the First International Symposium on Nuclear Fuel Elements (January 1959) form the basic part of this book on the development, design, and fabrication of nuclear fuel elements. Topics covered include element standardization and fabrication cost-analysis, as well as the physical and operational characteristics of elements. Appendices offer typical specifications and an extensive bibliography.

NUCLEAR TECHNOLOGY FOR ENGINEERS. By R. H. Ellis, Jr. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 284 pages, 6¼ by 9¼ inches, bound. $9.50. This guide covers four major areas of nuclear engineering: radiotracer technology, radiation, fission energy, and nuclear fusion. An explanation of the structure of the atomic nucleus and the disintegration of unstable nuclei is followed by the uses which modern technology makes of these properties. Low-level radiation, or radiotracer work, and high-level radiation are treated with regard to sources, effects, uses, and doses. Fission reactors and the engineering problems of building a reactor, a discussion of the different types of reactors, and a description of fusion, plasma physics, and fusion devices conclude the volume.

PLASMA PHYSICS AND THERMONUCLEAR RESEARCH, Volume 1. Edited by C. Longmire and others. Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y., 1959. 612 pages, 6 by 9½ inches, bound. $15. This first volume of Series XI of the edited *Proceedings* of the Second International Conference on the Peaceful Uses of Atomic Energy, 1958, is in four parts, each composed of individual papers. Part one constitutes a survey of recent work in Germany, Sweden, England, USSR, and the United States on controlled thermonuclear reactions. Part two examines particular devices used, such as the "Stellarator," the "Magnetic Mirror," "Plane Shock," and the "Pinched Discharge," and forms the major part of the book. The theoretical papers of part three discuss plasma equations and radiation, and hydromagnetic equilibria, and

part four deals briefly with some miscellaneous devices.

SPACE FLIGHT, Volume I. By K. A. Ehricke. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J., 1960. 513 pages, 6 by 9¼ inches, bound. $14.50. The concept of space flight and the environment in which it will take place is introduced through its historical aspects, followed by discussion of energy requirements in relation to gravitational and orbital conditions in the solar system, radiation and particles, and planetary and satellitory bodies in space. The second part of this work treats celestial mechanics from the viewpoint of the astronautical engineer. Summarized and tabulated data are included for use in research and development work, design, and systems analysis. The second and third volumes of "Space Flight," to follow shortly, will discuss space dynamics and operations.

THEORY AND DESIGN OF SMALL INDUCTION MOTORS. By C. G. Veinott. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York, N. Y., 1959. 477 pages 6¼ by 9¼ inches, bound. $15.50. An introductory text on the theory and design of induction motors sufficiently comprehensive for practicable design work, and well-supplied with references to advanced material. Successively treated are "Engineering Principles and Characteristics," "Theory and Performance Calculation Methods," "Evaluation of the Basic Motor Constants," and "Practical Design Procedures." The book provides material to assist in the training of engineers to design and apply small induction motors.

SYMPOSIUM ON MICROSCOPY. Published as Special Technical Publication No. 257, by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. 1959. 165 pages, 6¼ by 9¼ inches, bound. $4.75. The papers of this symposium on light and electron microscopy supplement the 1952 "Symposium on Light Microscopy" (ASTM-STP No. 143). Recent advances in microscopy are revised in a brief introduction, which also indicates that refinements and improvements are needed in sample handling and preparation techniques. Nine papers form the body of the symposium, discussing phase and interference microscopes; performance characteristics of objectives, eyepieces, and illuminators; and microscopy in the optical, petroleum, ceramic, mineral, and textile industries.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

QUANTUM ELECTRONICS, A SYMPOSIUM. A collection of research papers originally presented at the first symposium on Quantum Electronics, this book is a comprehensive review of the most recent developments in this fast-moving field. Topics covered include beam-type masers, solid-state masers, optical and infrared masers, and r-f masers. Optical pumping, parametric amplifiers, and paramagnetic resonance and its application to masers are considered. In addition, quantum effects in amplifiers and in communication, and the application of very sensitive masers to radio-astronomy are discussed. The more than 50 contributors to this symposium include researchers from Western Europe and the Soviet Union as well as scientists from the most important laboratories in the United States. The symposium is edited by C. H. Townes, professor of physics at Columbia University. It may be obtained from Columbia University Press, 2960 Broadway, New York 27, N. Y. Price $15.

ELECTRICAL EFFICIENCY IN INDUSTRIAL PLANTS. This practical engineering handbook is concerned with the problems of reducing electric power and lighting costs in industrial plants and commercial buildings. The book stresses the fact that waste and misuse of electric power is a major drain on efficiency and profit, and tells exactly how to make surveys of load, power factor, voltage, lighting, wiring, and electric protection. Instruments are discussed in detail, with emphasis on their selection, continued use, and maintenance. Full analysis of power costs is included, with particular attention to methods of lowering rates by minimizing peak demands. Many illustrations, diagrams, tables, and a checklist supplement the text. The volume is of interest to plant engineers, electrical engineers, electrical maintenance personnel, managers, supervisors, and all others concerned with electric system design, maintenance, and operation. Written by E. S. Lincoln, the 235-page book may be ordered from Dodge Books, 119 W. 40th St., New York 18, N. Y., for $9.50 a copy.

HOW TO USE METERS. To keep step with the newest in electronic equipment maintenance, this revised and greatly expanded edition presents accurate meter information. Written by J. F. Rider and S. D. Prensky, the most advanced developments, such as transistorized voltmeters, digital displays, refined laboratory instruments which provide greatly increased sensitivities, indication features in meters providing long-arc (250 degree) meter scales are brought to the reader in a concise presentation. Detailed information is given on the construction, operation, and application of all types of electric meters for electronic and electric equipment, and industrial applications. Careful attention has been given to the important extension of measurement capability in the new chapters on specialized measurements and advanced meter features. Available from John F. Rider Publisher, Inc., 116 W. 14th St., New York 11, N. Y., at $5.50.

THERMISTORS AND VARISTORS. This Veco Data Book covers thermistors; varistors; thermal conductivity cells; electronic controls; and thermal, electronic, and physical-sensing devices. It includes R vs. T curves and E vs. I curves plus additional information on Veco silicon carbide varistors including curves. The new edition offers engineers, purchasing and sales personnel, management and others responsible for their company's progress sufficient information to evaluate the needs in their own activities for thermistors, varistors, and allied devices. It is available from Victory Engineering Corp., 515 Springfield Rd., Union, N.J., for $1.

SCIENTIFIC INFORMATION ACTIVITIES OF FEDERAL AGENCIES. The National Science Foundation (NSF) is publishing a series of reports which describe the activities of the various agencies of the U. S. Government in providing scientific information to the public. One of the most valuable of these services is that of the Patent Office in publishing and making available technical knowledge contained in patents. This is described on pp. 17-23 of report NSF 59-58, Scientific Information Activities of Federal Agencies, November 1959, No. 5, United States Department of Commerce, Part I. It is useful as a source of information whereby the storehouse of applied technology in the Patent Office can be more fully utilized, and can also serve as a basis for explaining services of this office to inventors and others. It may be obtained from the Superintendent of Documents, U. S. Printing Office, Washington 25, D. C., for 15¢ per copy.

AMERICAN STANDARDS. *American Standard Minimum Requirements for Remote Dictation Through an Intercommunication Switching System*, X2.5.21-1959, establishes definitions, essential functions, and electrical requirements for remote dictation equipment and is available from American Standards Association (ASA) Dept. PR 115 at 35¢ a copy. A revision titled *Overhead-Type Distribution Transformers, 67,000 Volts and Below, 500 Kva and Smaller*, C57.12.20-1959, may be ordered from ASA Dept. PR 120 at $2.50 a copy. A revised edition of *American Standard Dimensional and Electrical Characteristics of 4-Watt T-5 Preheat-Start Fluorescent Lamp*, C78.400-1959, priced 35¢ a copy, has been approved and is obtainable from ASA Dept. PR 119, 70 E. 45th St., New York 17, N. Y.

IEC STANDARDS. Two new publications have been made available by the International Electrotechnical Commission. (1) IEC Publication No. 112, *Recommended method for determining the comparative tracking index of solid insulating materials under moist conditions*, indicates the relative behavior of solid insulating materials with regard to their susceptibility to surface tracking when exposed, under electric stress, to water and other contaminants from the surroundings, price $2.40; and (2) IEC Publication No. 72-1, *Recommendations for the dimensions and output ratings of electric motors, Part 1: Foot-mounted induction motors with shaft heights between 56 and 315 mm (2⅛ and 12½ inches)*. The recommendations of this publication apply only to foot-mounted a-c induction motors with shaft heights between 56 and 315 mm. for voltages up to 600 volts and for frequencies of 50 and 60 Hz (cps). It includes tables of standard dimensions, shaft extensions, and output ratings for these motors, price $2.40. Both publications may be ordered from the American Standards Association, Dept. PR 117, 70 E. 45th St., New York 17, N. Y.

COMPILATION OF ASTM STANDARDS ON COPPER AND COPPER ALLOYS B-5; 1959. This compilation contains 137 standards of which 17 are new, revised, or have had their status changed since the previous edition in 1957. In addition to standards for cast and wrought copper and copper alloys, the book contains some material on nonferrous materials for electric conductors, certain selected specifications on nonferrous metals and alloys for primary forms of copper, zinc, lead, and nickel used in copper-alloy products. The standards include methods of test, definitions, specifications, classifications, and recommended practices applicable to copper and copper alloys, filler material, pipe, tubes, wire, rod, bar, shapes, die forgings, plate, sheet strip, and rolled bar. Copper-alloy ingots and castings are also covered. Copies of this book may be obtained from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., at $7.50 each.

OTS PUBLICATIONS. Publication of quarterly supplements of its electronics reliability design handbook, temporarily suspended in January 1959, has been resumed by the U. S. Navy Bureau of Ships. The name of the handbook has been changed from NEL Reliability Design Handbook to *Navy Reliability Design Handbook*, PB 121839, and may be ordered from Office of Technical Services (OTS) for $3, the supplements on subscription at $2.25 a year or individually at 75¢ a copy. In addition, OTS has released the following reports: *Resistors, Fixed, Ultra-High Temperature, Radiation Resistant*, PB 161081, for Wright Air Development Center, U. S. Air Force, July 1959, 47 pages, price $1.25; *Design for Ease of Maintenance, Second Symposium on Electronics Maintenance*, PB 161107, May 1956, 208 pages, price $3.50; *Improved K-Band Semiconductor Mixer Diode*, PB 151970, U. S. Air Force, June 1959, 97 pages, price $2.25; *Research on Field Emission Cathodes*, PB 151960, May 1959, 73 pages, price $2; *Experimental Study of Cascade Backward-Wave Magnetron Amplifier at Low Levels*, PB 151829, January 1959, 38 pages, price $1; *Thermistor Infrared Detectors- Part I—Properties and Developments*, PB 151767, for Bureau of Ordnance, U. S. Navy, April 1958, 130 pages, price $2.75; *Analysis of Ionospheric Vertical Soundings for Electron Density Profile Data*, PB 151378, NBS Technical Note No. 14, July 1959, 15 pages, price 50¢; *Efficiency of a Thermomagnetic Generator*, PB 151796, Naval Research Laboratory, June 1959, 9 pages, price 50¢; *Apparatus for Measurement of the Magnetic Threshold Curves for Superconductors*, PB 151877, March 1959, 19 pages, price 50¢. All these publications may be ordered from OTS, U. S. Department of Commerce, Washington 25, D. C.

ENGLISH-RUSSIAN, RUSSIAN-ENGLISH ELECTRONICS DICTIONARY. Published to aid the English-speaking researcher, translator, writer, editor, or engineer who has occasion to use Russian language publications on electronics and telecommunication, this dictionary contains a collection of about 22,000 Russian terms and abbreviations in the various fields of electronics. It also includes explanations of peculiar Soviet terms and concepts, which strictly speaking have no equivalent in Western terminology. This 944-page dictionary, Catalog No. D 101.11:30-545 may be ordered from Superintendent of Documents, Government Printing Office, Washington 25, D. C., for $3.50.

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Cast Alnico Magnets are most commonly made in Alnico V, VI or III. Sintered Alnico Magnets usually are made in Alnico II, V or VI. Special permanent magnet materials supplied by Arnold include Vicalloy, Arnox III and V, and Cunife.

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New & Improved Products

(Continued from page 22A)

Calibration Console . . .

Model *61* was designed for fast, accurate calibration or standardization of a-c and d-c instruments. Providing an accuracy of 0.05% of indicated value, the console features simplified switching networks which permit nonskilled operators to calibrate

instruments accurately and quickly compared with two or more skilled technicians usually required with conventional calibration equipment. *Daystrom, Inc., Weston Instruments Division, 614 Frelinghuysen, Ave., Newark 12, N.J.*

K-Band Magnetron . . .

Extremely short pulses of 0.02 μsec with peak power output of more than 25 kw and extremely small size and weight are the important features of the new Amperex magnetron. Designed for service as a pulsed oscillator at a fixed frequency in the K-band, it is especially suited for use in high

definition and short-range radar systems up to 5 miles. Direct applications will be in airports, harbors, and river radar systems where extreme resolutions at short distances are needed. Military use will be in reconnaissance mapping in bad weather when aerial photographs cannot be taken. *Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L.I., N.Y.*

(Continued on page 30A)

NOW

Alcoa aluminum patented integral web channel bus available in 8 sizes

You can now get all the advantages of aluminum integral web channel bus in a new broad range of sizes.

This patented* design, introduced by Alcoa in 1956, has been expanded to eight sizes, providing capacities from 2,800 to 12,000 amperes.

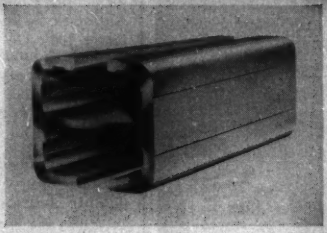
The web construction provides an integral shape for a bus conductor having unusual mechanical strength and high electrical efficiency. The large section modulus offers high structural strength to resist external loading and short-circuit stresses. The economical disposition of metal provides high current-carrying capacity at a low cost.

Moreover, you can make joints, taps, and splices by clamping, bolting, or welding. The table shows the sizes, capacities and weights from which you can choose to meet your exact needs.

Additional sizes can be designed to meet other specific needs. For complete information, contact your Rome representative. Or, if you'd like a copy of our "Alcoa Aluminum Bus Conductor Handbook," write: Rome Cable Division of Alcoa, Dept. 3-40, Rome, N. Y.

*PATENT NO. 2,904,621

Size	Nominal Current† (amperes)	Wt./ft. (lbs.)
4 x 4	2,800	5.4
4 x 6	3,500	7.1
5 x 6	4,050	8.9
5 x 8	5,000	11.7
6 x 6	5,000	14.2
8 x 8	7,000	19.0
11 x 11	10,000	31.0
12 x 12	12,000	38.0



†Based on 30°C rise above 40°C ambient still air

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New & Improved Products

(Continued from page 26A)

Diode Switch . . .

A silicon p-n-p-n diode capable of switching several watts of power at extremely high speeds will find immediate applications in line pulsers and high-speed gates for certain types of telephone equipment now under development. Turn-on and turn-off time is approximately 10 musec including the 4 musec storage time of the charge carriers. *Bell Telephone Laboratories, 463 West St., New York 14, N.Y.*

Voltage Regulator . . .

Fully transistorized, this voltage regulator contains no moving parts and was designed for use on constant-speed alternators rated to 480 volts, 50–60 cycles. The regulator includes an on-off switch, voltage-adjusting

rheostat, cross-current resistor for 3-phase units, and a potential transformer for voltages to 480 volts. The Autostatic is also available for single-phase 400-cycle, and d-c applications. *Lake Shore Electric Corp., 500 Willis St., Bedford, Ohio.*

Insulation . . .

A new insulation called *800* Rod exhibits unusually high dimensional stability under conditions of extreme moisture. As insulating pins in temperature-control dials of electric frying pans and other washable household appliances, the product will provide greater stability of factory-set heat-control calibrations. Available in bulk form of either linen or paper base, the product can also be fabricated by the supplier to precise user dimensions. *Spaulding Fibre Co., Inc., 310 Wheeler St., Tonawanda, N.Y.*

Telemetering Supervisory Systems and Associated Channels

This revised report (Vol. 1, Parts 1, 2, and 3) was prepared by subcommittees of the AIEE Committee on Telemetering in the Instrumentation Division and is intended as a guide to technical information in the telemetering field, including stationary or point-to-point telemetering, mobile telemetering, etc.

Part 1 is on Telemetering, Part 2 is on Supervisory Systems, and Part 3 is a numbered bibliography starting prior to 1920 up to 1958. At the end of the bibliography is an alphabetical listing of authors by number.

The 71-page booklet, S-111, is available for $2.50 from

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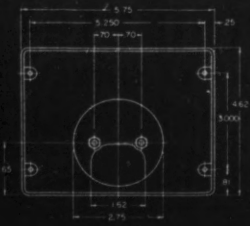

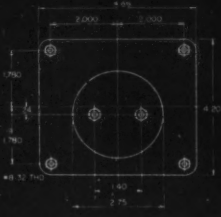

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For full information, or for the address of your nearest distributor, contact your local Weston representative . . . or write to Weston Instruments Division, Daystrom, Incorporated, Newark 12, N. J. *In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ont. Export: Daystrom's International Sales Division, 100 Empire St., Newark 12, N. J.*

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The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, etc., to 10-30 cps which frequency modulates a built-in audio tone channel. AC 10 to 30 cps or relay outputs are also available. Receiver detects and demodulates transmitted signal, generating a DC mv for operation of recorders or indicating instruments. Up to 45 telemeters can be multiplexed.

Any communication link, including power line carrier, microwave or wire line may be used.

Over-all accuracy is 1% with a response speed of 1 second. Equipment features a built-in calibration circuit for 10% and 90% receiver check, and 10 cps and 30 cps transmitter check.

Any quantity which may be converted into a DC millivoltage or will operate a slidewire may be telemetered.

WE CAN HELP YOU
Our Applications Department is ready to assist you in your control, telemetering or communications problem. Phone DEerfield 4-3100.

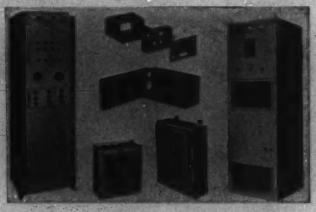
Write for Technical and Application Data.

Radio Frequency
LABORATORIES, INC.
Boonton, New Jersey, U.S.A.

Industrial Notes...

Keystone Manufacturing Co. Warren, Mich. . .

Keystone Manufacturing Co. has completed the expansion of its Special Products Division to offer a complete design, engineering, and fabrication service for all types of custom wiring enclosures. The company has complete facilities to produce a wide variety of enclosures to meet unusual installation requirements. To produce the custom enclosures, the firm has increased their machine tool facilities and added an extensive stock of special tooling, including dies for producing all sizes of single and multiple concentric knockouts. Also, the company



maintains tooling to produce openings such as rounds, rectangles, notches, clusters, etc., in any size or shape to customer specifications. According to the company, this recent expansion program enables them to give extremely fast quotation and deliveries on any type of wiring application problem. Quotations are based on customer blueprints, sketches, or specifications. For complete information, a 4-page brochure, no. B-159-B, covering the Special Products Division is available from Keystone Manufacturing Co., 23328 Sherwood Rd., Warren, Mich.

Yardney Electric Co. New York, N.Y. . .

A new type of compact, powerful battery has helped tell the story of man's latest exploration into outer space during the Navy's Strato-Lab IV balloon flight to study Venus. Called the Yardney Silvercel battery, it is manufactured by Yardney Electric Corp., 40-50 Leonard St., New York, N. Y. A number of the Silvercel battery packs were used to power the telemetering and data-recording equipment used on the Strato-Lab flight. Five times more energy can be had from the Silvercel battery's silver-zinc couple than from a similar-size ordinary battery.

Allis-Chalmers Washington, D.C. . .

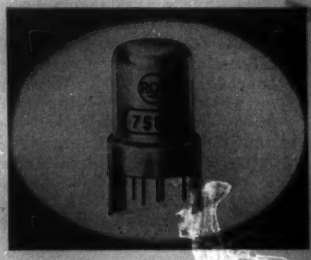
The Italian Committee for Nuclear Research has announced that its heavy-water research reactor has been brought to its full operating power of 5,000 kw. The reactor went critical in 1959. Allis-Chalmers Manufacturing Co. Nuclear Power Department, Washington, D.C., designed and constructed the reactor, which is located at Ispra, 40 miles north of Milan Italy. This research reactor was designed primarily for scientific investigation and provides neutrons for basic research.

Federal Pacific Electric Co. Newark, N.J. . .

A 35,000-square-foot plastics processing plant has been opened by Federal Pacific Electric Co. in Newark, N. J. The latest addition to Federal Pacific's Newark manufacturing complex, this facility will compound, preform, mold, and machine-finish plastic components for the company's lines of circuit breakers, switches, fusible service equipment, instruments, and metal-clad switchgear. Plant capacity is 500,000 pounds of molding compound per month.

Radio Corp. of America New York, N.Y. . .

The nuvistor, a thimble-size electron tube is now being produced commercially. The tube is said to be useful in many diverse applications ranging from data processing systems to

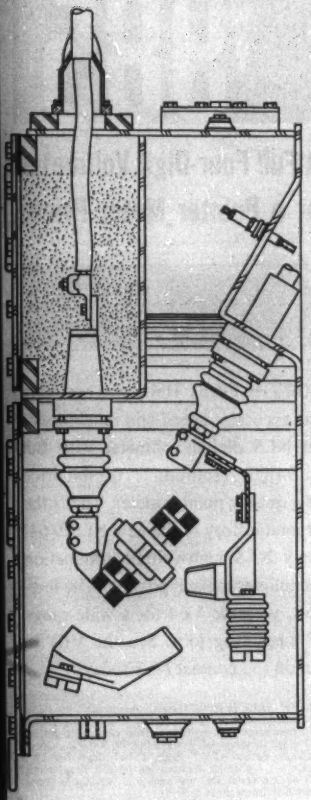


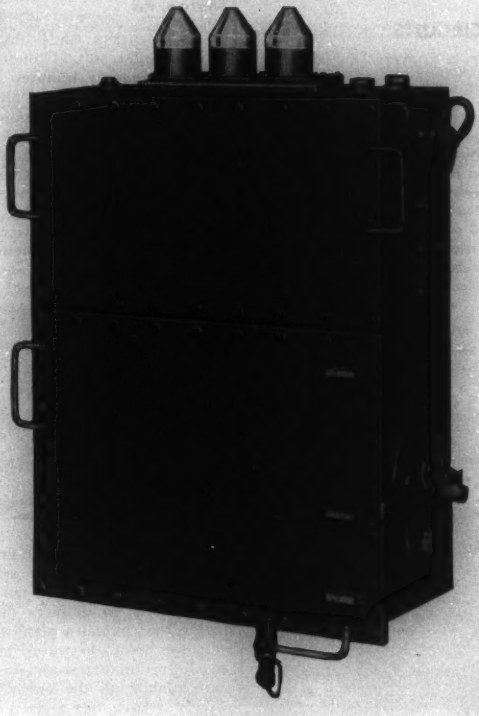
medical diagnostic equipment. Because the nuvistor has the ability to operate at any altitude, it will have important applications in miniaturized airborne apparatus and space vehicles.

(Continued on page 36A)

THE G&W THINLINE SWITCH

reduces space requirements and costs on network transformers





Here's a switch that has everything to your advantage. On your next transformer, it will help to reduce space requirements and installation costs. The unit occupies little more than seventeen inches from front to back. In spite of these reductions no sacrifice has been made in the electrical characteristics or in the usual G&W high standards of construction.

The Thinline may be welded or bolted to the transformer. Ready access to the cable terminating compartment permits ease of installation for three single conductor (as shown) or a three conductor cable. Transformer connections are made through the sealed porcelain tubes in the angle pocket. One or two electrical interlocks are optional and grounding contacts permit connection of "A," "A-B" or "A-B-C" phases of the cable in sequence or in a simultaneous connection of the latter.

The dielectric medium may be either oil or askarel.
The switch illustrated is rated 15 kv, 400 amperes.
Contact a G&W representative for full details.

G&W ELECTRIC SPECIALTY COMPANY
3500 WEST 127TH STREET • BLUE ISLAND, ILLINOIS

CANADIAN MFR. • POWERLITE DEVICES, LTD. • TORONTO, MONTREAL & VANCOUVER

D580

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An introduction to linear circuits for students of electrical engineering. Assumes an introductory course in physics and concurrent calculus. Noteworthy features include: a balanced treatment of time and frequency domain methods; an integrated treatment of Fourier series and integrals, Laplace transforms, and power density spectra; and coverage of topics seldom found in books at this level, such as signal flow graphs, relaxation methods, dummy variables, s-plane plots, and complex resonance.

c. 400 pp, 1,000 illus, to be published Summer 1960—probable price $9.50

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By DAVID K. CHENG,
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Proceedings of the IRE
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Applied Mechanics Reviews
534 pp, 150 illus, 1958—$9.75

ENGINEERING SYSTEMS ANALYSIS

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"The second-order linear differential equation . . . is treated in detail for mechanical, electrical, and acoustical systems . . . offers excellent introductions to dimensional analysis, feedback and control, and analog and digital computers."

Physics Today
223 pp, 98 illus, 1958—$7.50

ADDISON-WESLEY PUBLISHING COMPANY, INC.
Reading, Massachusetts

Industrial Notes

(Continued from page 32A)

Sharon Steel Corp. Sharon, Pa. . .

Steel orders which take days to process under normal conditions soon will require only minutes, as the result of the installation at Sharon Steel Corp. of the first International Business Machines Corp. (IBM) computer system of its type in the steel industry employing complete order entry, facilities loading, scheduling, inventory control, billing, and invoicing programs. Improved customer service through swifter, more accurate scheduling and

processing of orders is the first benefit expected from the new system, enabling the company to assign and hold more closely to delivery dates. Ultimately the company plans to process all paper work, to record adequately all production dates, and to assemble and schedule all the orders the company may have over a given period of business. Also planned is the feeding of data to the equipment on which important managerial, sales, market research, purchasing, metallurgical, research, engineering, and production decisions can be based.

Poly Chem Indianapolis, Ind. . .

A specially prepared formulation of molybdenum disulfide, Poxylube, is easily applied by any of the usual methods of painting such as spraying, brushing, or dipping. The dried film provides permanent solid film lubrication on all types of rotating and sliding bearing surfaces. Poxylube produces outstanding lubricity, and formerly unobtained adhesion, to metals with no more surface preparation than simple degreasing. This amazing property enables industrial users to adopt this unusual lubricating system to existing products without major production modification. Poly Chem, 541 S. Webster, Indianapolis 19, Ind.

(Continued on page 38A)

$985

A Full Four-Digit Voltmeter at a Pointer Meter Price!

FOR THE FIRST TIME you can have the accuracy, speed and reliability of an NLS digital voltmeter with full four-digit resolution . . . for the price of a quality pointer meter. That's the dramatic story of the new NLS V64! Only NLS high-volume production techniques make it possible. Use low-cost, versatile V64 for a wide range of measuring jobs. See the V64 in action . . . contact NLS today!

BRIEF SPECIFICATIONS: Accuracy ±(.02% of reading plus 1 digit) . . full 4-digit resolution . . . measures DC voltages from one millivolt to 500 volts in steps of ±9.999/99.99/500.0 . . . one package design (5¼" high, 15¼" deep for 19" rack) . . . plug-in accessories permit measuring AC or low-level DC voltages . . . available from stock for immediate delivery.

NLS *Originator of the Digital Voltmeter*

non-linear systems inc.
DEL MAR (SAN DIEGO), CALIFORNIA

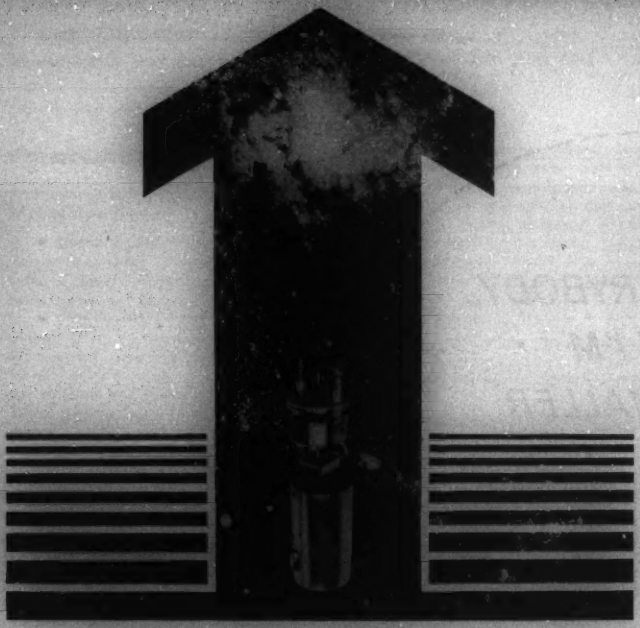
NLS — The Digital Voltmeter That Works . . . And Works . . . And Works!

LOOK, EVERYBODY, NOW I'M 54% SMALLER

225 amp breaker in new FJ frame size. 70 to 225 amp continuous at 600 v, 2 or 3 poles. Interrupts 25,000 amp at 240 v, 15,000 amp at 600 v. Instantaneous trip adjustable externally.

Get all the details. Write today to I-T-E Circuit Breaker Company, Dept. SA, 1900 Hamilton St., Philadelphia 30, Pa.

I-T-E CIRCUIT BREAKER COMPANY



". . . Where there is no air
to resist their motions,
all bodies will move with the greatest freedom."

SIR ISAAC NEWTON *Principles of Natural Philosophy*

Today, almost three hundred years after Newton's *Principia* appeared, man is about to satisfy his centuries-old curiosity concerning space "where there is no air." First instruments went. Soon man himself will go.

Prior to man's undertaking sustained space voyages propulsion systems with efficiencies far exceeding those presently available must be developed.

The scientists and engineers at Electro-Optical Systems are in the advanced stages of research and development on what may well be a forerunner of practical space propulsion systems — the ion engine.

Other advanced research and development programs in areas vital to technological progress in space, military weaponry and industry include:

Energy Conversion Research and Advanced Power Systems
Heat Rejection in Space
Molecular Electronics
Optical Tracking and Guidance
Space Communications Systems
Exploding Wire Research

EOS has professional opportunities for Physicists, Mathematicians and Engineers.

ELECTRO-OPTICAL SYSTEMS, INC. E S 125 NORTH VINEDO AVE. PASADENA, CALIFORNIA

Industrial Notes

(Continued from page 36A)

Glastic Corp.
Cleveland, Ohio . . .

Use of Glastic Fiberglas reinforced polyester channel stock instead of wood for gantry crane cable carriers has eliminated an expensive fabricating procedure for the manufacturer. It also is meeting the user's need for a strong moisture-resistant material. The insulating channel stock has low water absorption (0.3% maximum) and great dimensional stability. A high-strength material, it meets National Electrical Manufacturers Association GPO-1 specifications for electrical insulation and has flame retardance

Courtesy Thibedeau Studio

recognized by Underwriters' Laboratories, Inc. The channel stock is supplied "off the shelf" virtually ready for use. Cost of material for the six lengths required (two each for the three supports) is about half the cost of processing wood. The insulating "lumber" is simply cut into the required 5-foot, 8½-inch sections. Then, the same procedure is followed as with wood. Holes are drilled for the bolts that support the cables and the channel stock is fastened to the angle iron which in turn is mounted on the crane. The 55-ton gantry shown in closeup, which operates on 3-phase 60-cycle 440-volt a-c, was manufactured by Whiting Corp., Harvey, Ill. The standard-size channel stock was supplied by Glastic Corp., Cleveland 21, Ohio.

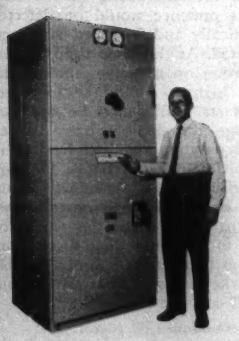
ITT
San Fernando, Calif. . .

A new facility for research and development of special microwave electron tubes has been established by International Telephone and Telegraph Corp. (ITT) at its Advanced Development Laboratory, San Fernando, Calif. The laboratory will focus its efforts on the development of tubes with special application to missile and aircraft electronics.

(Continued on page 40A)

NEW DRAW-OUT DESIGN
LIMITAMP* MOTOR CONTROL

INTERRUPTS IN ½ CYCLE



Rated 2300- to 4600-volts for a-c motors up to 3000 hp.

Here is performance you can count on . . . to start, stop and protect your motor under *your* environmental conditions!

General Electric's new draw-out Limitamp control is designed to interrupt in the first ½ cycle. Current is limited in the first ¼ cycle. EJ-2 fuses—the standard of excellence—give you this dependable short-circuit protection.

The new draw-out contactor is designed to give outstanding performance under all conditions of load—from small motors running light to large motors at "locked rotor." This improved performance comes from a new blow-out structure and an improved arc chute with superior extinguishing action.

The new contactor also meets a 60-kv base impulse level. Performance of the entire design has been exhaustively tested in General Electric's high-voltage laboratories . . . and, complete design coordination of bus, cable, current transformers, contactors, fuses, insulators and overload relays means top protection for men and equipment!

Ask your G-E Apparatus Sales Engineer or Agent about other advanced-design performance, maintenance, installation and operation features of new Limitamp control. Or, write Sect. 783-12, General Electric Co., Schenectady, N. Y. for Bulletin GEA-6893. Industry Control Dept., Salem, Va.

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GENERAL ELECTRIC

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REWARDING!

A feeling of accomplishment, comfortable salary, security, fine home, prestige in the community. Yes, these are the marks of a successful Motorola engineer in Chicagoland. But, what exactly makes a career at Motorola so rewarding—beyond the ordinary realm of material benefits?

Foremost is opportunity. For here a man is encouraged to use all of his creative talents to their fullest. He works on projects that spark vision, that inspire imagination. He works with men who recognize and respect his abilities . . . a calibre of men that he cannot help but admire.

Yes, a career at Motorola is deeply rewarding. You owe it to yourself to discover *exactly* how much. Simply clip the coupon below.

- Radar transmitters and receivers
- Radar circuit design
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- IF strip design
- Device using klystron, traveling wave tube and backward wave oscillator
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- VHF & UHF receiver
- Transmitter design and development
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- Sales engineering
- Design of VHF & UHF FM communications in portable or subminiature development
- Microwave field engineers
- Transistor switching circuit design
- Logic circuit design
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- Semi-conductor device development
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EQUAL JOB OPPORTUNITY For All Qualified Applicants

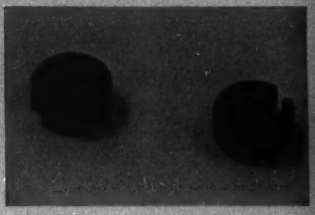
MOTOROLA Inc.

Industrial Notes

(Continued from page 38A)

Ferroxcube Corp. of America Saugerties, N.Y. . .

The company has expanded its facilities to meet the growing demand for its miniature type *332P* pot cores and to assure users of production quantities on short notice. These ⅛-inch-diameter pot cores, now widely used for pulse transformers and kindred applications, meet the assembly and mounting requirements of all



component manufacturers and are available in several varieties. Samples, in sufficient quantities to enable research and development engineers to conduct investigations in the light of their own specific application requirements, will be furnished promptly on request.

Ohio State University Columbus, Ohio . . .

An electronic warning and control system, a possible first step in the creation of the "automatic highway," currently is under development by Ohio State University scientists. The project makes use of recently developed logic circuits to warn drivers of various traffic conditions and to control traffic flow. In the plan, a highway would be divided into equal-size sectors. As an automobile passed each area, its presence would be detected electronically and its speed and location noted. At the same time, similar information on all other automobiles on the highway would be gathered. These facts would then be operated upon by the logic circuits which could determine potential hazards to the vehicles in each sector. Through use of visual or audible signals within the car or by use of automatic roadside signs, these conditions would be relayed to the individual driver concerned so that he then would be able to take the necessary corrective actions to avoid collisions.

(Continued on page 42A)

Exclusive with VAREX®

Varex is the *only* capacitor whose elements are totally free of mechanical insertions in the active dielectric!

Varex engineers have eliminated these mechanical insertions, or tabs, from the dielectric by means of the exclusive "extended foil" design. As shown above, every turn of foil extends beyond the paper dielectric and makes a broad contact with a plate under strong spring pressure.

This exclusive Varex design has thus removed a possible source of mechanical damage during winding, and a cause of higher electrical stress in the adjacent paper dielectric.

This means lower current density, cooler operation, and appreciably longer life for Varex capacitors!

OHIO BRASS COMPANY, MANSFIELD, OHIO

Ohio Brass

PORCELAIN INSULATORS • LINE HARDWARE • CAPACITORS • LIGHTNING ARRESTERS
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Professional Opportunities Are Available For

Electrical Engineers

with interest and experience in the following fields:

- Design and Development of:
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  Electronics
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For information please write to:
Personnel Manager

Brookhaven National Laboratory

UPTON, LONG ISLAND, N. Y.

BROOKHAVEN NATIONAL LABORATORY
A Center for Nuclear Research and Development
UPTON-NEW YORK

Industrial Notes

(Continued from page 40)

Union Carbide Plastics Co. New York, N.Y. . .

Union Carbide Plastics Co., Division of Union Carbide Corp., 420 Lexington Ave., New York 17, N. Y., has announced that the recently increased plant capacity at South Charleston, W. Va., for the production of polyvinyl ethyl ether resins, is now on stream. Polyvinyl ethyl ether resin is the binding force in the family of adhesives that maintain permanent "tackiness" and bonding strength. They have been described as "the adhesives that never grow old."

Tracerlab–Keleket Waltham, Mass. . .

Keleket's image intensifier systems now have an intensification factor of 3,000. This dramatic development is the result of the incorporation of a new high-gain, high-resolution intensifier tube into the system, thereby producing more than three times the gain found in conventional intensifying systems. Tracerlab–Keleket, 1601 Trapelo Rd., Waltham 54, Mass.

Airmatic Systems, Inc. Cleveland, Ohio . . .

A high-speed pneumatic tube system, which automatically routes medicines, test samples, diagnostic charts, and routine clerical material to any one of 32 destinations, links the widely separated stations at the new Mt. Sinai Hospital wing with four 4-inch-diameter tube networks. It was installed by Airmatic Systems, Inc., an International Telephone and Telegraph Corp. (ITT) associate, located in Cleveland, Ohio.

Sanders Associates, Inc. Nashua, N.H. . .

A series of new flexible wiring designs, including twisted pairs, shielded cables, and multilayer harnesses of high density circuits are available as mass-produced, unit components for equipment manufacturers. Cost reduction advantages in semiautomatic wiring of assemblies and subassemblies are offered by the new Flexprint (registered trade mark) wiring developments. Wave or fountain soldering and dip soldering may be used, as well as endless belt and infrared heating apparatus. Sanders Associates, Inc., 95 Canal St., Nashua, N. H.

AFTER 30 YEARS ON THE JOB . . . Okolite insulation still looks good. This unretouched photograph shows a section of 11.5 Kv power cable recently re-assigned by Duquesne Light Company. Note that the insulation is still flexible and resilient—workable. Tests made this year show the tensile strength has deteriorated very little, remaining more than 33% above the original specification figure.

30-year-old Okonite cable still tests above specification figures . . .

This is CABLE'BILITY *a new word for your vocabulary*

Cable'bility (ca'ble-bil'-i-ty) *new word. Noun.* 1. Ability to design and manufacture electrical cables that give outstanding performance. 2. Having long background and wide experience in cable research and application. 3. Possessing keen understanding of customers' problems. Implies eagerness to serve faithfully and dedication to progress. Syn. The Okonite Company.

This is Okonite Cable'bility at work. It's "Old Faithful"—a 1250 MCM, Okolite-insulated power cable made in 1929, now carrying on a new career as a mine power feeder for Duquesne Light of Pittsburgh.

"Old Faithful" began service as an 11.5 Kv lead from switchyard to transformer, handling 15,000 KVA loads. During World War II, it saw fifteen years of full load operation, 24 hours a day. Then in 1957 it was replaced with a larger cable to handle even greater loads. But it was found still suitable for demanding tasks as a power feeder.

There are Okonite "Old Faithfuls" in use today in every application . . . *yours* too. Because, as in 1929, Okonite still produces the most dependable cables on the market. The reason is Cable'bility. The Okonite Company, Subsidiary of Kennecott Copper Corporation, Passaic, N. J.

***where there's electrical power . . . there's* OKONITE CABLE**

6960-A

Trade Literature...

Proceedings of Technical Meetings . . .

This 29-page catalog lists and describes the published proceedings of 126 selected meetings, conferences, and symposia held during the past 10 years in which the Atomic Energy Commission or its contractors were sponsors, cosponsors, or major participants. The availability and price of the proceedings of each of the meetings listed are shown. The proceedings are grouped under 19 subject areas: accelerators, biology and medicine, chemistry, computers, controlled thermonuclear reactions, education, fission products, general subjects, heat transfer, hot laboratory practice, industrial hygiene, instrumentation, management, metallurgy, nuclear safety, nuclear ship propulsion, physics, reactors, and waste processing. *The Atomic Energy Commission, Technical Information Service Extension, P.O. Box E, Oak Ridge, Tenn.*

Rectifier News, Winter Edition . . .

An 8-page technical newsletter published by International Rectifier Corp. contains a 4-page article entitled "Properties of Semiconductor Devices Affecting Voltage Division," in which voltage distribution and various methods to achieve equality are discussed, analyzed, and recommendations made for the solution of specific problems. Write on letterhead requesting Rectifier News, Winter Edition, RW-1259, to *International Rectifier Corp. 1521 E. Grand Ave., El Segundo, Calif.*

Servo Analyzer Brochure . . .

A 4-page, 2-color brochure on the Metrolog *200* Series of servo analyzers describes how transfer function characteristics of a system or separate component can be measured quickly and easily through the complete and automatic reduction of gain—phase data between any two signals in the system or the input and output of the component. Details are given relative to direct readout and automatic plotting capabilities which provide frequency in cps, phase angle in degrees, and amplitude ratio in db. *Metrolog Corp., 169 N. Halstead St., Pasadena, Calif.*

(Continued on page 57A)

Exceptional

ENGINEERING OPPORTUNITY

With One of The Nation's Leading Growth Companies

AMERICAN-MARIETTA

A diversified company, American-Marietta has had 46 years of consistent, rapid growth and uninterrupted profitability based on progressive management, a continuous research and development program, and growth products in many fields: adhesives and resins, cement, lime and refractories, construction products, paints and finishes, printing inks, sealants, metallurgy, and environmental and control equipment. Three-quarters of our management group are technically trained.

Excellent position with our Central Engineering group in Chicago is now available for experienced engineer interested in long-range career opportunities, a variety of creative, challenging assignments, and complete responsibility for project development:

ELECTRICAL ENGINEER, graduate, with five to fifteen years experience in design, estimating, supervision of drawings and preparation of specifications for lighting and secondary power distribution systems and electrical and electronic controls of industrial processing plants.

This position provides attractive starting salary with liberal merit increases based on ability and initiative. A full program of benefits is available, including a company-sponsored educational program.

All replies confidential. Send resume to:

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American-Marietta Company

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Electrical Engineer

Project Development on New Ignition Systems

Leading international automotive parts manufacturer has challenging opportunity for a capable man. Experience in magnetic distributor or other high voltage devices, instrumentation and insulating materials associated with engine ignition. Sufficient theoretical electrical knowledge required for practical application in the development of this project.

This is an excellent opportunity for a creative man seeking the challenge to associate himself with an exciting new departure from tradition.

Qualified men send resume giving information regarding experience and salary requirements to:

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New York 18, N. Y.

PHYSICIST OR PHYSICAL CHEMIST

for Basic Research on Electrical Contacts and Brushes

One of the country's oldest and largest manufacturers of carbon, graphite, & metal powder products has opportunity for top-ranking scientist in a fundamental field where professional activities and technical papers are encouraged.

Work involves surface phenomena and the fundamental physical processes associated with friction and commutation. Work will be done in association with Dr. Ragnar Holm, a leading authority on contacts, in fully-equipped, new labs.

Company offers the usual fringe benefits and enjoyable living in the mountains of Pennsylvania. School and hospital facilities are excellent. Any age or degree of experience will be considered and salary will be in proportion. All replies held in strictest confidence. Send resume to:

Dr. E. I. Shobert, II,
Mgr. of Research

STACKPOLE CARBON COMPANY

St. Mary's, Pa.

Trade Literature

(Continued from page 46A)

Wall Chart of Conversion Factors . . .

A very useful reference table for engineers and other executives in wall chart form includes common conversions such as inches to centimeters or watts to hp as well as many conversions that are difficult to locate in reference manuals. For a free wall

chart of conversion factors, write *Precision Equipment Co., 4411E Ravenswood Ave., Chicago 40, Ill.*

Improved Transformer . . .

Four-page bulletin S-202C describes a new transformer, greatly reduced in size, with noise levels below National Electrical Manufacturers Association (NEMA) requirements. Single- and 3-phase units in ratings through 15 kva and 600 volts are designed with core and coil assemblies in steel weatherproof cases, completely filled with Standard Transformer Co. ERS compound. The compound filling results in rapid transfer of heat and extremely quiet operation. Wound core construction of high grade cold rolled silicon alloy steel results in low losses and good regulation. A roomy terminal compartment with knockouts in sides and bottom is provided. *Standard Transformer Co., Warren, Ohio.*

Instruction Booklets for Vacuum Pumps . . .

Three instruction booklets for installation, operation, and maintenance of high-vacuum pumps are Booklet HY-2A which covers the newer Cenco Hyvac *2*, *7*, and *14* mechanical vacuum pumps that utilize the internal vane principle, Booklet HY-1A that describes the conventional Cenco Hyvac Pump, a rotary type of oil-sealed unit which operates on the principle of the eccentric rotor with external moving vane, and Booklet PR-1A, that contains instructions for the Cenco Pressovac Pump which is a combination vacuum and pressure unit operating on a principle similar to the Hyvac but having rated vacuum of 15 microns and providing pressures to 10 psi. *Central Scientific Co., 1700 Irving Park Rd., Chicago, Ill.*

X-Ray Chart and Electron Microscope Folder . . .

An 11½- by 22-inch wall chart, showing 10 basic X-ray techniques used today for industrial quality control and scientific research shows a simplified diagram for each one of the techniques with explanatory notes and a brief discussion of the fields of application. Educational institutions and research laboratories can post the chart in conspicuous locations as a visual aid for employees. Also available is a 6-page folder, describing scientific investigations at Franklin Institute that involve a broad variety of electron microscope problems. *Philips Electronic Instruments, 750 S. Fulton Ave., Mt. Vernon, N. Y.*

Laminate Literature . . .

This specification sheet gives properties and prices for Glastic Resistrac fiberglas Alumina-Polyester, patented track-resistant insulation for service in humid, contaminated atmospheres. A companion sheet covers track resistance of Resistrac and five other laminates as tested under the dust-and-fog tracking resistance test procedure suggested by American Society for Testing Materials. Included in the material is a description of the test procedure. For copies of Glastic Resistrac Laminate literature, write *The Glastic Corp., 4321 Glenridge Rd., Cleveland 21, Ohio.*

Servomotor Test Report . . .

A comprehensive test report describing electrical and mechanical characteristics of Beckman (registered trade mark). Size 8 servomotors under various environmental conditions is expected to be of major interest to control engineers. The 14-page report describes the purpose and nature of the study as well as the apparatus employed. Actual test procedures are listed in detail and in the same sequence as they were performed. Finally, the data, results and conclusions are fully tabulated. *Helipot Technical Information Service, 2500 Fullerton Rd., Fullerton, Calif.*

(Continued on page 61A)

po-si'tion

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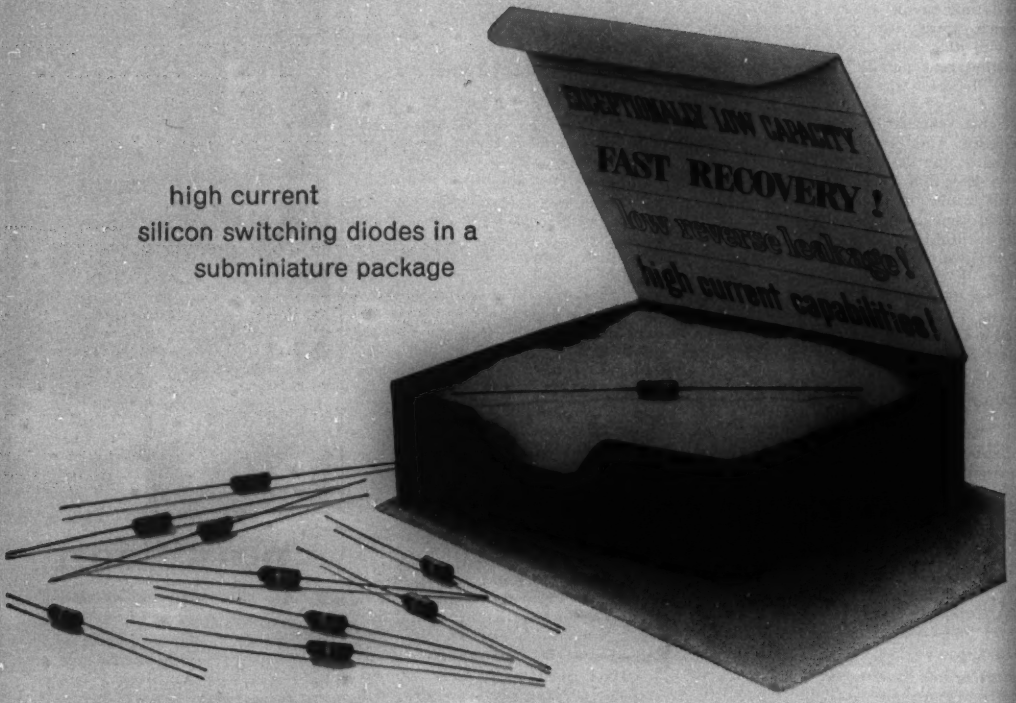

100 mA Min. @ 1V Forward Current...0.3 μsec recovery...4 μμf at −2V...now HUGHES can offer you these diode characteristics with no sacrifice in package size. Result: greater design flexibility for computer applications! With these characteristics, these diodes will cover practically every major computer switching requirement.

An added feature: the ability of these diodes to handle high current with a fast recovery time makes it possible to use them in many general purpose applications, as well as computers. With their hermetically sealed glass envelopes, these HUGHES* diodes have been engineered for extreme reliability under adverse environmental conditions.

TYPICAL SPECIFICATIONS:

Type	Min. Es (@ 100μA)	Min. Fwd. Current @ 25°C (@ +1.0V)	Max. Reverse Current (μA) @ 25°C	Max. Reverse Current (μA) @ 100°C	Reverse Recovery Rev. Resist. (R) (ohms)	Reverse Recovery Max. Rec. Time (μsec)
1N837	100	150	0.1 @ — 75V	15 @ — 75V	400 K	0.5*
1N838	150	150	0.1 @ —125V	15 @ —125V	400 K	0.5*
1N839	200	150	0.1 @ —175V	15 @ —175V	400 K	0.5*
1N840	50	150	0.1 @ — 40V	15 @ — 40V	400 K	0.3*
1N841	150	150	0.1 @ —120V	15 @ —120V	400 K	0.3*
1N844	100	200	0.1 @ — 80V	15 @ — 80V	400 K	0.5*
Improved Standards						
1N643A	200	100	.025 @ — 10V	5 @ — 10V	200 K	0.3†
1N662A	100	100	1.0 @ — 10V	20 @ — 10V	100 K	0.5†
1N663A	100	100	0.1 @ — 75V	15 @ — 75V	200 K	0.3†

*Measured in JAN test circuit and switched from 30mA forward current to —35V.
†Measured in JAN test circuit and switched from 5mA forward current to —40V.
Typical capacitance: C_{-10} = 2.2 μμf $C_{-1.5}$ = 4.4 μμf C_{-0} = 3.0 μμf
Operating temperature range: —65°C + 150°C Storage temp. range: —65°C + 200°C

For additional information concerning these unique HUGHES diodes call or write the Hughes sales office or distributor nearest you. Or write Hughes, Semiconductor Division, Marketing Department, Newport Beach, California. For export write: Hughes International, Culver City, California.

Creating a new world with ELECTRONICS

HUGHES

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Trade Literature

(Continued from page 57A)

Wire and Cable Specification Sheets . . .

Four simple, composite, color-coded data charts that are easy to use and time saving are: the price sheet, which gives list prices, stranding, strand diameters, temperature ratings, cutting and paralleling charges, and reel deposits; the weight sheet, with net weights, standard shipping weights, standard put-ups, shipping lengths, and reel dimensions and weights; the diameter and wall thickness sheet that gives over-all diameters, with insulation and jacket wall thicknesses; and the specification sheet, giving listings of most used specifications, their issuing agencies, the types of wires in the specifications with their voltage rating and approval numbers. Write Dept. F. M., *Hatfield Wire & Cable Division, Continental Copper & Steel Industries, Inc., Hillside 5, N.J.*

"Who Gets Hurt?" . . .

"Who gets hurt in industrial accidents?" is a question asked and answered by a 16-page pamphlet published by the National Safety Council using a humorous approach, multi-colored cartoons, and concise text to discuss on-the-job injuries. A copy of "Who Gets Hurt?" may be obtained free from the *National Safety Council, 425 N. Michigan Ave., Chicago 11, Ill.*

Dry-Type Transformer Brochure . . .

An informative brochure on the manufacture of quality sound-rated dry-type transformers, entitled "The Profile of Sorgel Electric Co.," is composed of product illustrations, transformer data, and manufacturing facts. According to the company, this literature will be of interest and benefit to anyone who buys, sells, or specifies dry-type transformers. *Sorgel Electric Co., 838 W. National Ave., Milwaukee 4, Wis.*

Bulletin on Control Panels . . .

Selection of the right control panel for a wide variety of automatic materials-handling systems is the subject of 12-page, illustrated bulletin G-9 offered by Fuller Co. The four basic types, the "walk-in" master control panel, the floor and wall-mounted types, and the explosion-proof type are described. *Fuller Co., Catasauqua, Pa.*

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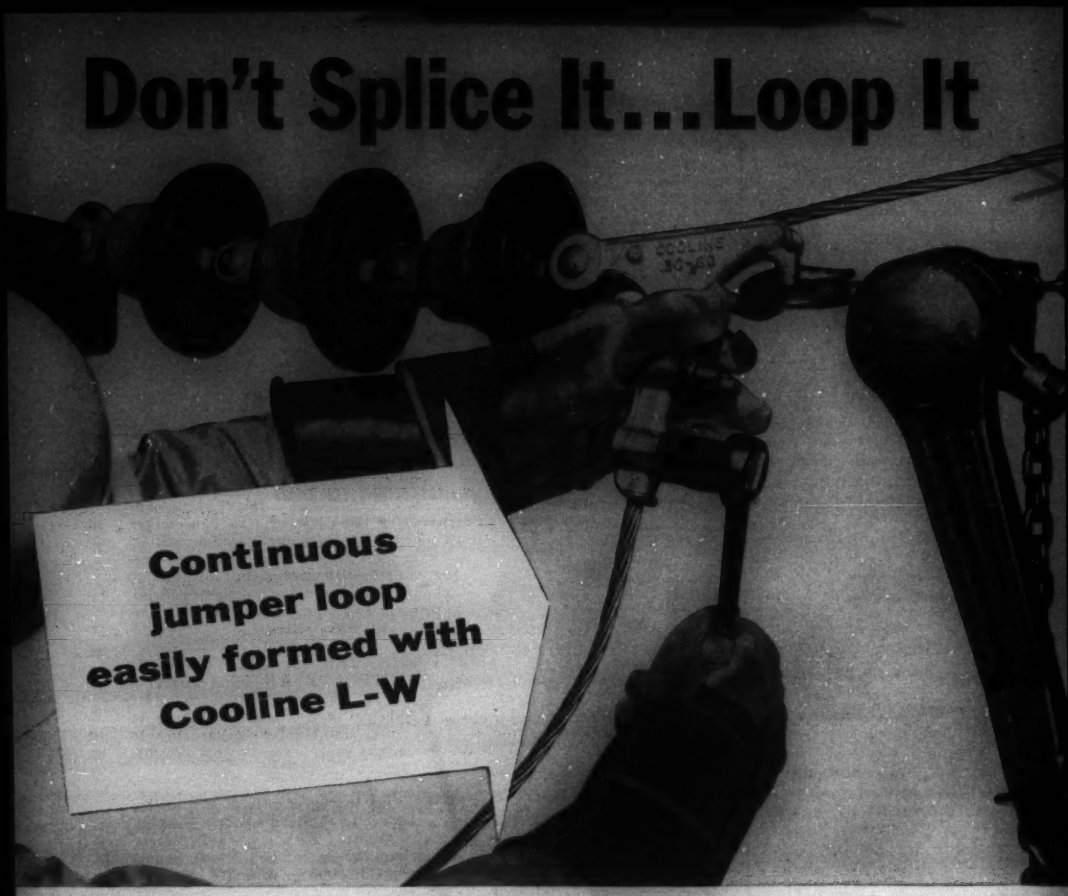

When Cooline L-W clamps are used on distribution deadends, trouble-free jumper loops can be formed quickly, efficiently without cutting or splicing the conductor.

Low-cost Cooline L-W clamps offer many of the advantages of heavy duty Cooline clamps for transmission lines, but are especially designed for the distribution and sub-transmission trend toward larger conductors and shorter spans.

The L-W clamp has a powerful snubbing action which has high holding power without crushing the conductor. The six models in the series cover a range from .2 to 1.3 inches in conductor diameter with more than adequate ultimate strengths.

Installation is simple since no special tools or skills are required. A few minutes with a standard wrench and Cooline L-W clamps are ready to serve the life of the line.

Just look at these many advantages: design that permits the use of continuous jumper loop without splicing conductor . . . convenience . . . high, maintained holding power . . . low installed cost. And the aluminum construction minimizes electrical losses and conductor heating.

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